Draft Implementation Plan for Bacterial TMDLs in the Back Bay Watershed

1/26/2009

TABLE OF CONTENTS

1.0 EXECUTIVE SUMMARY

1.1 Introduction

This Implementation Plan (IP) is a companion document to the report, "Development of Bacterial TMDLs for the Virginia Beach Coastal Area,"(Map Tech 2005). The TMDL Study set allocations to limit bacteria pollutant loads discharged to London Bridge Creek and Canal #2, Milldam Creek, Nanney Creek[1], West Neck Creek (Middle) and West Neck Creek (Upper) to levels that were modeled to achieve compliance with the state water quality criteria for bacteria for contact recreational use. This IP bridges the gap between those specified pollutant load allocations and actual reductions in bacteria counts in impaired waters within the Back Bay Watershed by recommending a set of actions to be taken in the watersheds during a fifteen year project timeframe. Currently, Nanney Creek is the only impaired waterbody within the Back Bay Watershed to have a completed TMDL. This IP will be updated as other TMDLs within the Back Bay Watershed are completed. Actions to reduce bacteria in London Bridge Creek, Canal #2, and West Neck Creek (Upper) were included in "Implementation Plan for the Fecal Coliform Total Maximum Daily Load (TMDL) for Shellfish Areas of Lynnhaven Bay, Broad Bay and Linkhorn Bay Watersheds." Actions to reduce bacteria in Milldam Creek and West Neck Creek (middle) are included in "Implementation Plan for Bacterial TMDLs in the North Landing River Watershed."

State and Federal Requirements

Two sets of regulatory requirements for the development of TMDL IPs are applicable in the state of Virginia.

- Virginia Water Quality Monitoring, Information and Restoration Act of 1997 (WQ MIRA)

- §303(d) of the Federal Water Pollution Control Act of 1972 commonly known as the Clean Water Act (CWA)

WQMIRA requires the State to develop reports assessing water quality of state waters, to provide data to develop programs addressing water quality impairments, to develop TMDLs and to develop IPs. CWA strives "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." The inception of the federal TMDL program is found in section 303(d) of that legislation.

---

[1] The TMDL Study referred to this waterbody as Nawney Creek, but the name of this creek should be changed to Nanney Creek. This document will refer to this waterbody as Nanney Creek to reflect the wishes of the Southern Rivers Watershed Stakeholders.

1.2 Review of Virginia Beach Coastal Area TMDLs

Table 1-1: TMDL Reduction in Fecal Coliform Loadings from Existing Conditions
(Stage 1 reductions as calculated in the TMDL Study)

Waterbody	Direct Wildlife	Forest/Wetlands	Agriculture	Straight Pipes	Urban
Nanney Creek	0	0	15%	100%	50%

The core of this IP is a set of actions found in Section 6 aimed to reduce the levels of fecal coliform bacteria in Nanney Creek. The actions chiefly target bacteria from human and pet ("anthropogenic") sources. This reflects the staged implementation recommended by the Virginia Department of Environmental Quality and referenced in the TMDL Study.

1.3 Public Participation

Two public meetings were held in the watershed to engage the public in the development of the TMDL Implementation Plan for the Southern Rivers Watershed. The first meeting was held on May 16, 2007 at Creeds Elementary School in Virginia Beach. A work group composed of representatives from city departments, the Hampton Roads Planning District Commission (HRPDC), local citizens, and state and federal agencies was formed to guide development of the TMDL IP. The second public meeting was held on January 26, 2009 at Creeds Elementary School in Virginia Beach.

1.4 Implementation Actions

The management actions outlined in this IP capitalize on existing and planned programs and efforts within the Southern Rivers Watershed and will be implemented in three phases. Phase I will include a reexamination of the land use data and current sources contributing to the impairment of the waterbodies as well as a public information campaign to educate citizens in the watershed about water quality issues and how they can help reduce fecal coliform loadings to the waterbodies. Phase II activities are those that should take place within the next five years but may not have approved funding sources yet. Phase III actions may require regulatory changes, but they may be implemented as necessary if Phase I and Phase II actions do not significantly improve water quality within the study area. Management actions were divided into the following ten management categories:

- Agricultural BMPs
- Sanitary Sewer System Improvements
- Stormwater Programs
- Boating Programs

- Pet Waste Programs
- Erosion and Sediment Control
- Aquatic Resources Restoration
- Education Programs
- Land Use Management
- Wildlife Contribution Controls

1.5 Associated Costs and Benefits

The primary benefit of the implementation of the management actions described in this IP is the reduction of bacteria levels in Nanney Creek. The programs and actions contained within this IP will serve to reduce the anthropogenic sources of bacteria within the Back Bay Watershed. Because many of the programs mentioned in this report also serve purposes other than to just reduce bacteria and because they cover areas larger than the Back Bay Watershed, the costs of reducing bacteria levels in the watershed can be difficult to estimate. City of Virginia Beach staff estimated costs for management categories using knowledge of current program costs and best professional judgment.

1.6 Measurable Goals and Milestones

The goal of the TMDL developed for Nanney Creek is to bring the impaired water segments within the Back Bay Watershed into compliance with the water quality standard for bacteria in recreational waters. Once the water segment achieves compliance with the bacteria criteria, then the segment can be removed from the 303(d) Impaired Waters List. Throughout the fifteen year project timeframe, DEQ will continue its monthly monitoring of stations throughout the watershed. Currently, this monitoring program includes 2 stations on Nanney Creek. Project progress will be tracked throughout the timeframe of the implementation plan, and the effectiveness of the management actions proposed in this IP will be evaluated at the end of five, ten, and fifteen years.

1.7 Stakeholders Roles and Responsibilities

Stakeholders are individuals who live or have land management responsibilities in the watershed, including government agencies, businesses, private individuals and special interest groups. Stakeholder participation and support is essential for achieving the goals of this TMDL effort. Stakeholders for this project were identified at the beginning of IP development and invited to sit on the Workgroup for the project.

1.8 Watershed Planning Efforts

The City of Virginia Beach, through a contract with URS Corporation, has conducted a ground truthing in the Nanney Creek subwatershed to compare these findings with the source assessment from the TMDL Study. The results from this field assessment will guide the Implementation efforts in the Nanney Creek subwatershed. Similar field assessments will also be completed in the Milldam Creek and West Neck Creek (middle) subwatersheds in the adjacent North Landing River Watershed to verify the need for similar Implementation actions in those areas.

1.9 Potential Funding Sources

One of the objectives of this TMDL Implementation Plan was to maximize utilization of existing programs and resources to achieve the goal of reducing bacteria levels within the Back Bay Watershed. In general funding for these programs and the management actions described in this IP will come from four sources:

- Locality funds
- Private / nonprofit funds
- Virginia State funds
- Federal funds

2.0 INTRODUCTION

2.1 Purpose, Scope, and Timeframe

This Implementation Plan (IP) is a companion document to the report, "Development of Bacterial TMDLs for the Virginia Beach Coastal Area," completed by Map Tech, Inc. for the Virginia Department of Environmental Quality (DEQ) in April 2005, which will henceforth be referred to as the TMDL Study. The IP creates a framework to achieve the reductions in bacteria counts recommended in the TMDL Study. The core of this IP is the set of actions presented in Section 6 intended to reduce the levels of fecal coliform bacteria in Nanney Creek[2] from controllable sources. The goal of the IP is compliance with the State of Virginia water quality standard for bacteria for primary contact recreational use. This IP follows the State guidance for TMDL implementation plans published by DEQ. This TMDL and Implementation Plan are the second of many to be completed within the jurisdiction of the City of Virginia Beach. This document follows the development of the "Implementation Plan for the Fecal Coliform Total Maximum Daily Load for the Shellfish Areas of Lynnhaven Bay, Broad Bay, and Linkhorn Bay Watersheds" which the City has chosen to serve as a framework for subsequent TMDL Implementation Plans.

The TMDL study that was approved by the US Environmental Protection Agency (USEPA) in September 2005 and the Virginia State Water Control Board in September 2006 examined the watersheds, their characteristics, and the sources of fecal coliform throughout the watersheds. Using monthly monitoring data, bacterial source tracking (BST), and a tidal volumetric model, DEQ was able to assign maximum allowable loads to each source in the watersheds in order to bring Nanney Creek into compliance with the water quality standard. This IP outlines a strategy and the proposed actions to reduce anthropogenic loading of bacteria to the level set forth in the TMDL study in order to comply with the water quality standard for fecal coliform for contact recreation. The proposed actions included in this IP will be performed by the City of Virginia Beach in cooperation with state, federal, and non-governmental entities. These actions are expected to be completed within a fifteen year timeframe.

The pollutant reductions in the Nanney Creek subwatershed will be implemented in a staged fashion. Staged implementation is an iterative process that first addresses those sources with the largest impact on water quality. Stage 1 management actions will target the controllable, anthropogenic bacteria sources identified in the TMDL, setting aside control strategies for wildlife except for cases of over population. During the implementation of the Stage 1 scenario, all controllable sources will be reduced to the maximum extent practicable using an iterative approach. DEQ will re-assess water

---

[2] The TMDL Study referred to this waterbody as Nawney Creek, but the name of this creek should be changed to Nanney Creek. This document will refer to this waterbody as Nanney Creek to reflect the wishes of the Southern Rivers Watershed Stakeholders. Efforts are underway to officially change the name of the Creek.

quality data during and subsequent to the implementation of the Stage 1 scenario to determine if the water quality standard is attained.

Stage 1 implementation management actions will be divided into three phases. Phase I will include a reexamination of the land use data and current sources contributing to the impairment of the waterbodies as well as a public information campaign to educate citizens in the watershed about water quality issues and how they can help reduce fecal coliform loadings to the waterbodies. Phase II activities are those that should take place within the next five years but may not have approved funding sources yet. Phase III actions may require regulatory changes, but they can be implemented as necessary if Phase I and Phase II actions do not significantly improve water quality within the study area. Stage 1 implementation actions are discussed in greater detail in Section 6.

The TMDL may be reevaluated by DEQ after implementation of Stage 1 management actions or if new information on water quality or hydrodynamics in Nanney Creek becomes available. Only DEQ can revise a TMDL; the decision tree for approval and revision of the TMDL and Implementation Plan are outlined in Figure 2-1.

In some water bodies for which TMDLs have been developed, water quality modeling indicates that even after removal of all bacteria sources (other than wildlife), the water body will not attain standards under all flow regimes at all times. The TMDL scenarios for Nanney Creek show that water quality standards in these water bodies should be met without reductions in bacteria from direct wildlife sources. However, because the TMDL allocates bacteria by land use rather than source, water quality standards may not be achieved without some reduction in wildlife load from residential areas.

Virginia and EPA are not proposing the elimination of wildlife to allow for the attainment of water quality standards. While managing over populations of wildlife remains as a limited option to local stakeholders, the reduction of wildlife or changing of a natural background condition is not the intended goal of a TMDL. If water quality standards are not being met after implementation of Stage 1 management actions, then it may be determined through a Use Attainability Analysis (UAA) that primary contact recreation is not a viable use for Nanney Creek. The UAA process is discussed in greater detail in Section 6.2.

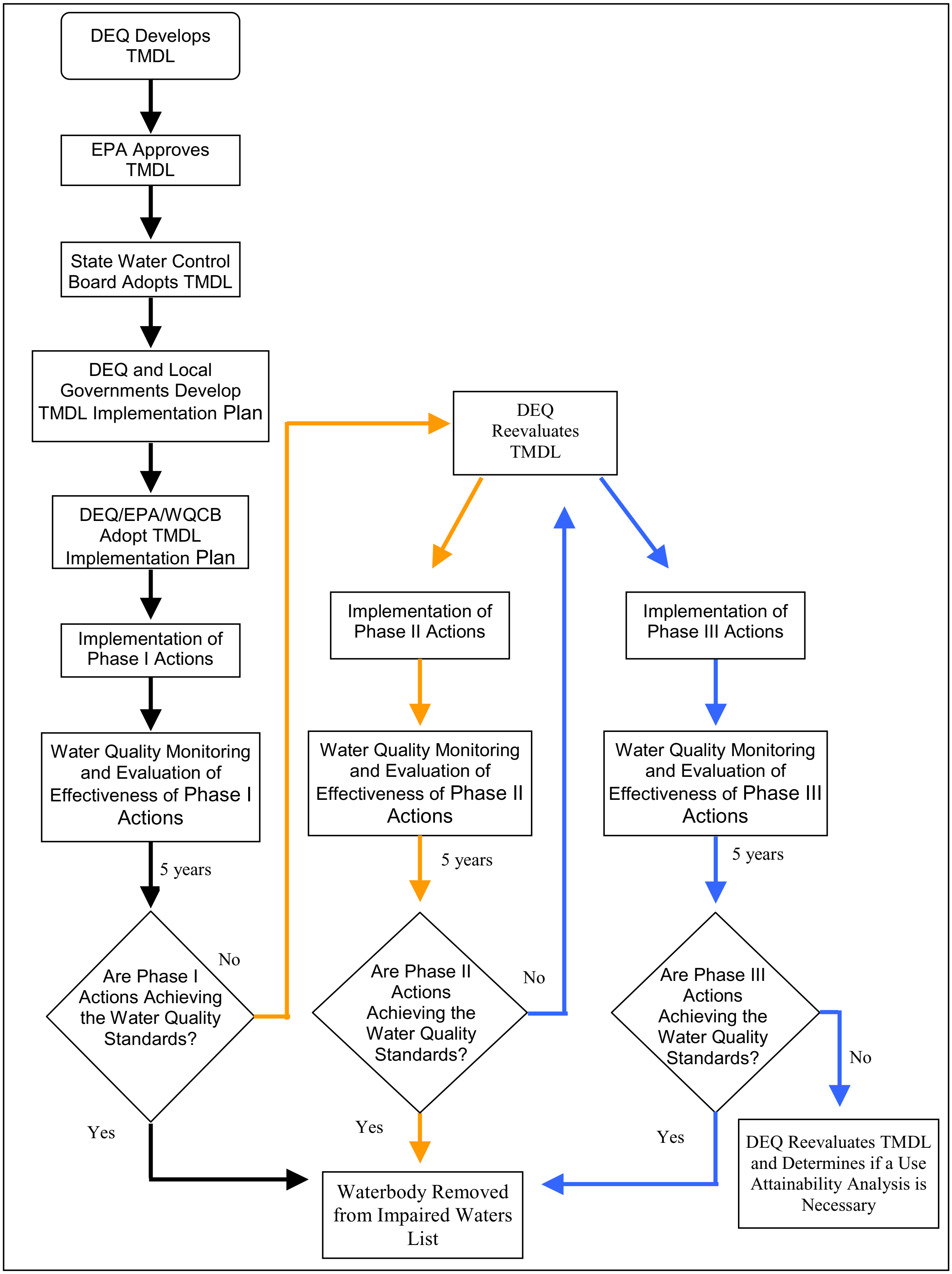


Figure 2-1: Decision Tree for Approval and Revision of TMDLs

2.2 Regulatory Background

Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for water bodies which are exceeding water quality standards. TMDLs represent the total pollutant loading that a water body can receive without violating water quality standards. Water quality standards are numeric or narrative limits on pollutants that are developed to ensure the protection of human health and aquatic life. The TMDL process establishes the allowable loading of pollutants for a water body based on the relationship between pollution sources and in-stream water quality conditions. By following the TMDL process, states can establish water quality based controls to reduce pollution from both point and non-point sources to restore and maintain the quality of their water resources (EPA 1991).

In accordance with Federal regulations at 40 CFR § 130.7, a TMDL must comply with the following requirements: (1) designed to attain and maintain the applicable water quality standards, (2) include a total allowable loading and as appropriate, wasteload allocations (WLAs) for point sources and load allocations for nonpoint sources, (3) consider the impacts of background pollutant contributions, (4) take critical stream conditions into account (the conditions when water quality is most likely to be violated), (5) consider seasonal variations, (6) include a margin of safety (which accounts for uncertainties in the relationship between pollutant loads and instream water quality), (7) consider reasonable assurance that the TMDL can be met, (8) be subject to public participation.

Once a TMDL is developed and approved by EPA, measures must be taken to reduce pollution levels in the stream. These measures, which can include the use of better treatment technology and the installation of best management practices (BMPs), are implemented in a staged process that is described along with specific BMPs in the IP. In general, the Commonwealth intends for the pollutant reductions to be implemented in a staged fashion. Staged implementation is an iterative process that first addresses those sources with the largest impact on water quality.

2.3 Designated Use and Water Quality Standard

Nanney Creek was identified by the Virginia DEQ through assessment monitoring data as not meeting the fecal coliform standard for recreational use. According to Virginia Water Quality Standards (9 VAC 25-260-5), the term "water quality standards means provisions of state or federal law which consist of a designated use or uses for the waters of the Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and serve the purposes of the State Water Control Law (§62.1-44.2 et seq. of the Code of Virginia) and the federal Clean Water Act (33 USC §1251 et seq.)."

According to Virginia Water Quality Standards (9 VAC 25-260-10A), "all state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish)."

Section 9 VAC 25-260-170 is the applicable water quality criteria for fecal coliform impairments in the Albemarle watershed. Prior to 2002, Virginia Water Quality Standards specified the following criteria for a nonshellfish supporting waterbody to be in compliance with Virginia's fecal standard for contact recreational use:

> *A. General requirements. In all surface waters, except shellfish waters and certain waters addressed in subsection B of this section, the fecal coliform bacteria shall not exceed a geometric mean of 200 fecal coliform bacteria per 100 ml of water for two or more samples over a 30-day period, or a fecal coliform bacteria level of 1,000 per 100 ml at any time.*

If the waterbody had an exceedance rate > 10.5% and had at least 2 exceedances, the waterbody was classified as impaired and the development and implementation of a TMDL was indicated in order to bring the waterbody into compliance with the water quality criterion. Based on the sampling frequency, only one criterion was applied to a particular datum or data set. If the sampling frequency was one sample or less per 30 days, the instantaneous criterion was applied; for a higher sampling frequency, the geometric criterion was applied. This was the criterion used for listing the impairments included in this study. Sufficient fecal coliform bacteria standard violations were recorded at VADEQ water quality monitoring stations to indicate that the recreational use designations are not being supported.

The EPA has since recommended that all states adopt an *E coli* or *enterococci* standard for fresh water and *enterococci* criteria for marine waters by 2003. EPA is pursuing the states' adoption of these standards because there is a stronger correlation between the concentration of these organisms (*E. coli* and *enterococci*) and the incidence of gastrointestinal illness than with fecal coliform. *E. coli* and *enterococci* are both bacteriological organisms that can be found in the intestinal tract of warm-blooded animals. Like fecal coliform bacteria, these organisms indicate the presence of fecal contamination. The adoption of the *E. coli* and *enterococci* standard went into effect January 15, 2003 in Virginia. The new criteria, used in developing the bacteria TMDL in this study, is outlined in 9 VAC 25-260-170 and reads as follows:

> *A. In surface waters, except shellfish waters and certain waters identified in subsection B of this section, the following criteria shall apply to protect primary contact recreational uses:*
>
> *1. Fecal coliform bacteria shall not exceed a geometric mean of 200 fecal coliform bacteria per 100 ml of water for two or more samples over a calendar month nor shall more than 10% of the total samples taken during any calendar month exceed 400 fecal coliform bacteria per 100 ml of water. This criterion shall not apply for a sampling station after the bacterial indicators described in*

subdivision 2 of this subsection have a minimum of 12 data points or after June 30, 2008, whichever comes first.

2. E. coli and enterococci bacteria per 100 ml of water shall not exceed the following:

Standard	***Geometric Mean[1]***	***Single Sample Maximum[2]***
Freshwater[3] *E. coli*	*126*	*235*
Saltwater and Transition Zone[3] *Enterococci*	*35*	*104*

[1] For two or more samples taken during any calendar month.
[2] No single sample maximum for *enterococci* and *E. coli* shall exceed a 75% upper one-sided confidence limit based on a site-specific log standard deviation. If site data are insufficient to establish a site-specific log standard deviation, then 0.4 shall be used as the log standard deviation in freshwater and 0.7 shall be as the log standard deviation in saltwater and transition zone. Values shown are based on a log standard deviation of 0.4 in freshwater and 0.7 in saltwater.
[3] See 9 VAC 25-260-140 C for freshwater and transition zone delineation.

2.4 Nanney Creek TMDL Efforts

In response to Section 303(d) of the CWA, the Virginia Department of Environmental Quality (DEQ) listed Nanney Creek as impaired on Virginia's Section 303(d) list for being unable to attain the criteria for primary contact recreation due to elevated levels of fecal coliform bacteria.

A TMDL study for Nanney Creek was completed by DEQ in April 2005 and approved by the US Environmental Protection Agency (USEPA) in September 2005 and the Virginia State Water Control Board in September 2006. The TMDL study examined the watersheds, their characteristics, and the sources of fecal coliform throughout the watersheds. Using monthly monitoring data, bacterial source tracking (BST), and a tidal volumetric model, DEQ assigned maximum allowable loads to each source in the watersheds in order to bring Nanney Creek into compliance with the water quality standard for primary contact recreation.

2.5 Nanney Creek Subwatershed

The Virginia Beach Coastal Area contains both wind-driven and tidally driven systems. Nanney Creek is described as a "wind tidal tributary" and shares hydrologic connectivity with other wind tidal, and lunar tidal bodies of water (City of Virginia Beach, 2003). However, Nanney Creek is basically riverine in structure, and is known to receive substantial flow inputs from stormwater runoff in its contributing area. The location of Nanney Creek is shown in Figure 2-1.

For the period from 1953 to 2004, the portion of the Virginia Beach Coastal Area near the Back Bay Wildlife Refuge received an average annual precipitation of 45.08 inches, with 56% of the precipitation occurring during the May through October growing season.

Average annual snowfall is 3.1 inches, with the highest snowfall occurring during January. Average annual daily temperature is 59.9 ºF. The highest average daily temperature of 85.9 ºF occurs in July, while the lowest average daily temperature of 31.7 ºF occurs in January.

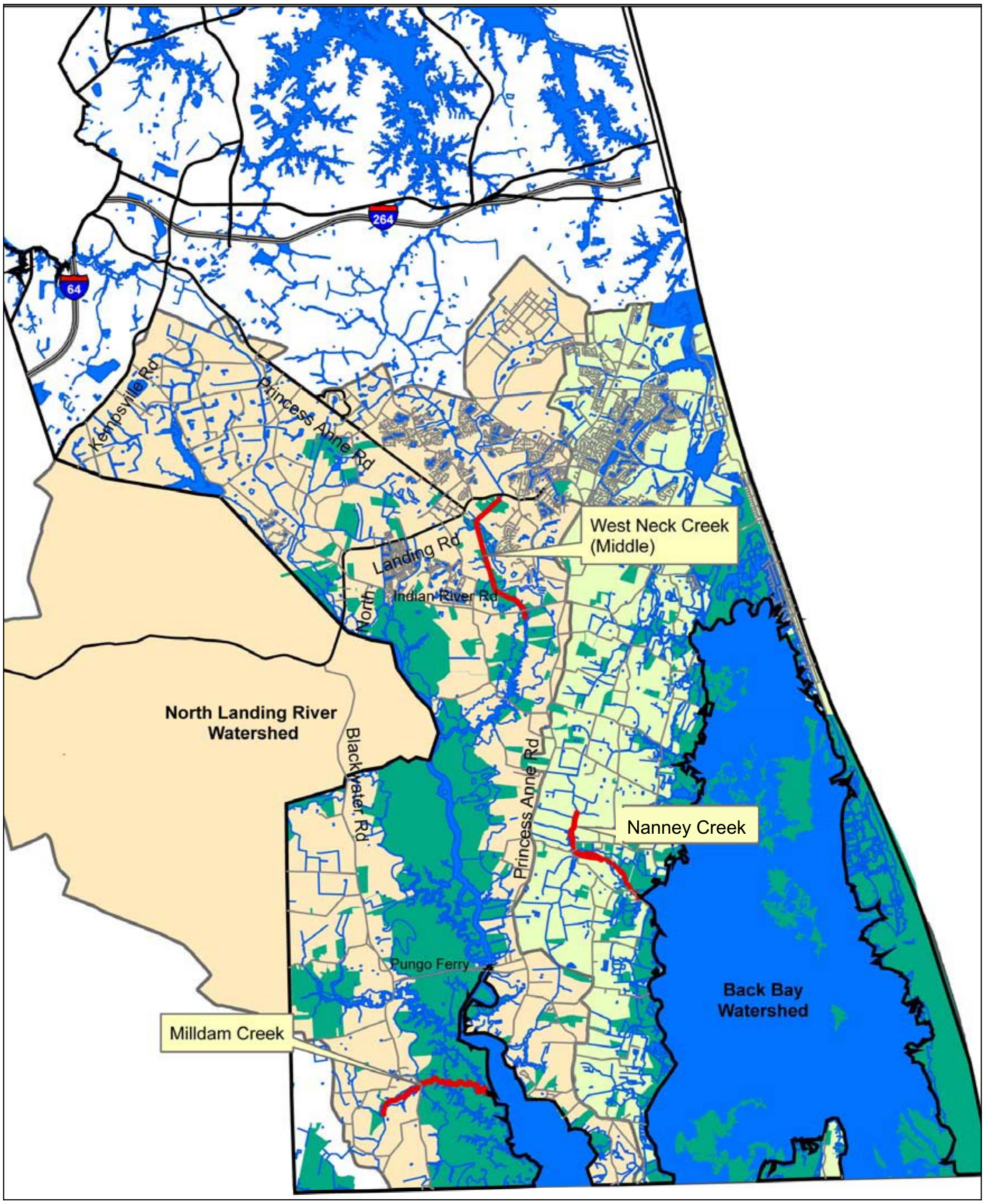


Figure 2-1: Location of Nanney Creek.

3.0 STATE AND FEDERAL REQUIREMENTS

3.1 Background

There are two sets of regulatory requirements for the development of TMDL Implementation Plans (IPs) in the state of Virginia.

- Virginia Water Quality Monitoring, Information and Restoration Act of 1997 (WQ MIRA)
- §303(d) of the Federal Water Pollution Control Act of 1972 commonly known as the Clean Water Act (CWA)

3.2 State Requirements

The TMDL Implementation Plan is a requirement of Virginia's 1997 Water Quality Monitoring, Information, and Restoration Act (§62.1-44.19:4 through 19:8 of the Code of Virginia), or WQMIRA. WQMIRA directs the Virginia Department of Environmental Quality (DEQ) to "develop and implement a plan to achieve fully supporting status for impaired waters." In order for Implementation Plans to be approved by the Commonwealth, they must include the following:

- Date of expected achievement of water quality objectives;
- Measurable goals;
- Necessary corrective actions;
- Associated costs, benefits, and environmental impact of addressing the impairment.

3.3 Federal Requirements

Section 303(d) of the CWA and current EPA regulations do not require the development of implementation strategies. EPA does, however, outline the minimum elements of an approvable IP in its 1999 "Guidance for Water Quality-Based Decisions: The TMDL Process". The listed elements include:

- A description of the implementation actions and management measures,
- A time line for implementing these measures,
- Legal or regulatory controls,
- The time required to attain water quality standards, and
- A monitoring plan and milestones for attaining water quality standards.

3.4 Federal Consent Decree

The Commonwealth of Virginia was a signatory to the June 11, 1999 consent decree settling federal case no. 98-979-A “American Canoe Association, Inc. and the American Littoral Society v. USEPA and USEPA – Region III.” By signing the consent decree, Virginia committed to develop TMDL studies by 2010 for all Virginia water segments listed on the 1998 303(d) Impaired Waters list.

4.0 REVIEW OF TMDL DEVELOPMENT

4.1 Description of Watershed Characteristics

The Nanney Creek subwatershed is located in the Southeastern portion of the City in the Back Bay Watershed and drains directly to Back Bay. The 7.43 square mile subwatershed is predominantly agricultural in nature with some rural residential development. The watershed is primarily comprised of cropland, wetlands and pasture. Land use is summarized in Table 4-1 and illustrated in Figure 4-1. Nanney Creek is considered an estuary that generally flows in an eastern direction, but is influenced by wind effects and exhibits some bi-directional flow. The impaired segment begins 0.8 miles upstream from the Nanney Road crossing and ends 0.92 miles downstream from the Nanney Road crossing (0.52 square miles).

Table 4-1: 2000 Land Use

Landuse	Nanney Creek
Water	2.5%
Residential	2.8%
Commercial/Services	0.9%
Barren	0.0%
Woodland	4.2%
Pasture	14.8%
Cropland	50.9%
Wetlands	22.3%
Livestock Access	1.6%

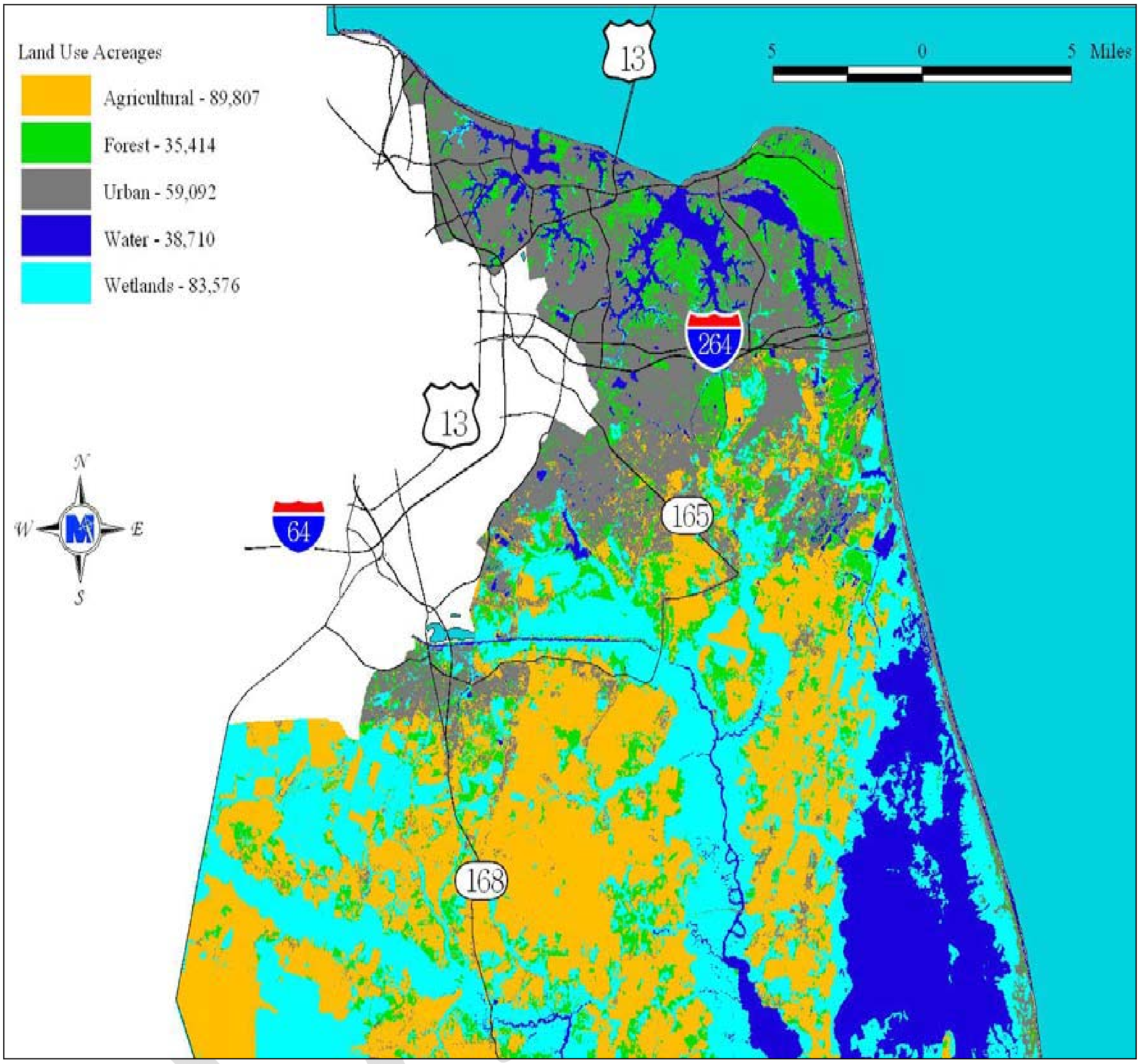


Figure 4-1 Virginia Beach Land Use (2000)

4.2 Description of Impairment

Nanney Creek, was identified by the Virginia DEQ through assessment monitoring data as not meeting the fecal coliform standard for recreational use.

Table 4-2: Fecal Bacteria Impairments in the Back Bay Watershed Listed In 2004 305(b)/303(d) Water Quality Assessment Integrated Report For which TMDLs were Developed (DEQ 2004)

TMDL ID	Waterbody Name	Impairment	Initial List Date	City/County	Size
VAT-K42E-01	Nanney Creek (upper)	Fecal Coliform	1996	Virginia Beach	.03 mi^2
VAT-K42E-02	Nanney Creek (lower)	Fecal Coliform	1996	Virginia Beach	.06 mi^2

Table 4-3 TMDL Endpoints

Stream Name	Listing Criterion	TMDL Endpoint
Nanney Creek	Fecal coliform	enterococci

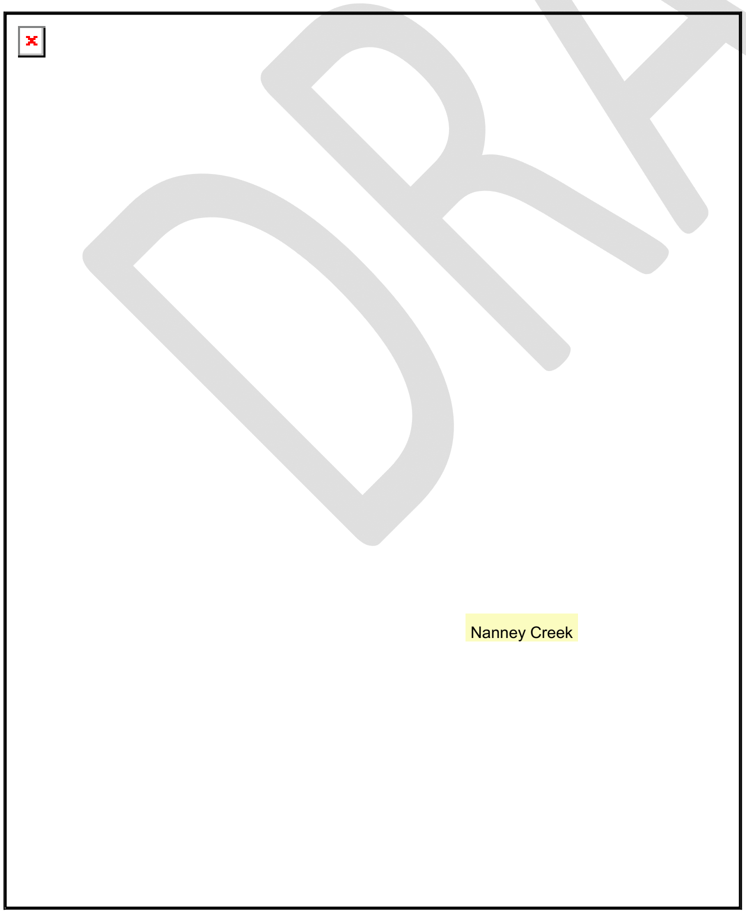


Figure 4-2: Impaired Waters Map

4.3 Description of Water Quality Monitoring

Virginia DEQ analyzes bi monthly water quality sampling at 2 locations on Nanney Creek (Figure 4-3). Samples are collected by the Back Bay Restoration Foundation. Data from in-stream fecal coliform samples were analyzed from February 1968 through March 2004 and are included in the analysis. Table 4-4 summarizes the fecal coliform samples collected at the in-stream monitoring stations used for TMDL assessment.

In order to facilitate the development of the TMDL, one station in Nanney Creek was selected for a special study to determine the sources of fecal coliform bacteria. This TMDL study collected bacterial samples at this station on a monthly basis from July of 2003 through June of 2004 and used bacterial source tracking (BST) to estimate the source contributions.

BST is used to identify bacterial contributions from anthropogenic and background sources, such as wildlife, for which no precise loading value exists. The TMDL study BST analysis used the Antibiotic Resistance Approach (ARA), to partition the sources of fecal coliform to the water body. ARA uses fecal streptococcus or Escherichia coli (E. Coli) and patterns of antibiotic resistance for partitioning sources. The premise is that human, domestic animal, and wild animal fecal bacteria will have significantly different patterns of resistance to the battery of antibiotics used in this test. The ARA was used to estimate the percent loading per source category to the water. The five major source categories that were used in the TMDL study were human, pets, livestock, mammalian wildlife, and birds.

The BST results of water samples collected at the ambient station in Nanney Creek are reported in Table 4-5 and Table 4-6. The *E. coli* enumerations are given to indicate the bacteria concentrations at the time of sampling. The proportions reported are formatted to indicate statistical significance (*i.e.*, **BOLD** numbers indicate a statistically significant result). The statistical significance was determined through 2 tests. The first was based on the sample size. A z-test was used to determine if the proportion was significantly different from zero (alpha = 0.10). Second, the rate of false positives was calculated for each source category in each library, and a proportion was not considered significantly different from zero unless it was greater than the false positive rate plus three standard deviations. Table 4-6 summarizes the results for each station with load-weighted average proportions of bacteria originating from the four source categories. The load-weighted average considers the level of flow in the stream at the time of sampling, the concentration of *E.coli* measured, and the number of bacterial isolates analyzed in the BST analysis. The full BST report for Nanney Creek is located in Appendix B of the TMDL report.

It should be noted that BST methods are still being developed and there are substantial limitations of this study that should be considered when using the BST results. BST is not a quantitative tool and was only intended to be used to identify and estimate potential source loads to the study area. The accuracy of results using the ARA method is dependent on the size and relevance of a library of potential bacteria sources. Libraries are expensive and time consuming to build and libraries created for surrounding areas proved inadequate. The small library used in this study could have contributed to unidentified sources for some samples. Another limitation of this study was the number of isolates tested in some samples. Numbers may not be precise in samples where less than 10 isolates were used to determine the source loading. Another concern is the use of E. coli as the test organism. Additional research has shown that enterococci is a more effective indicator for BST (DEQ 2004).

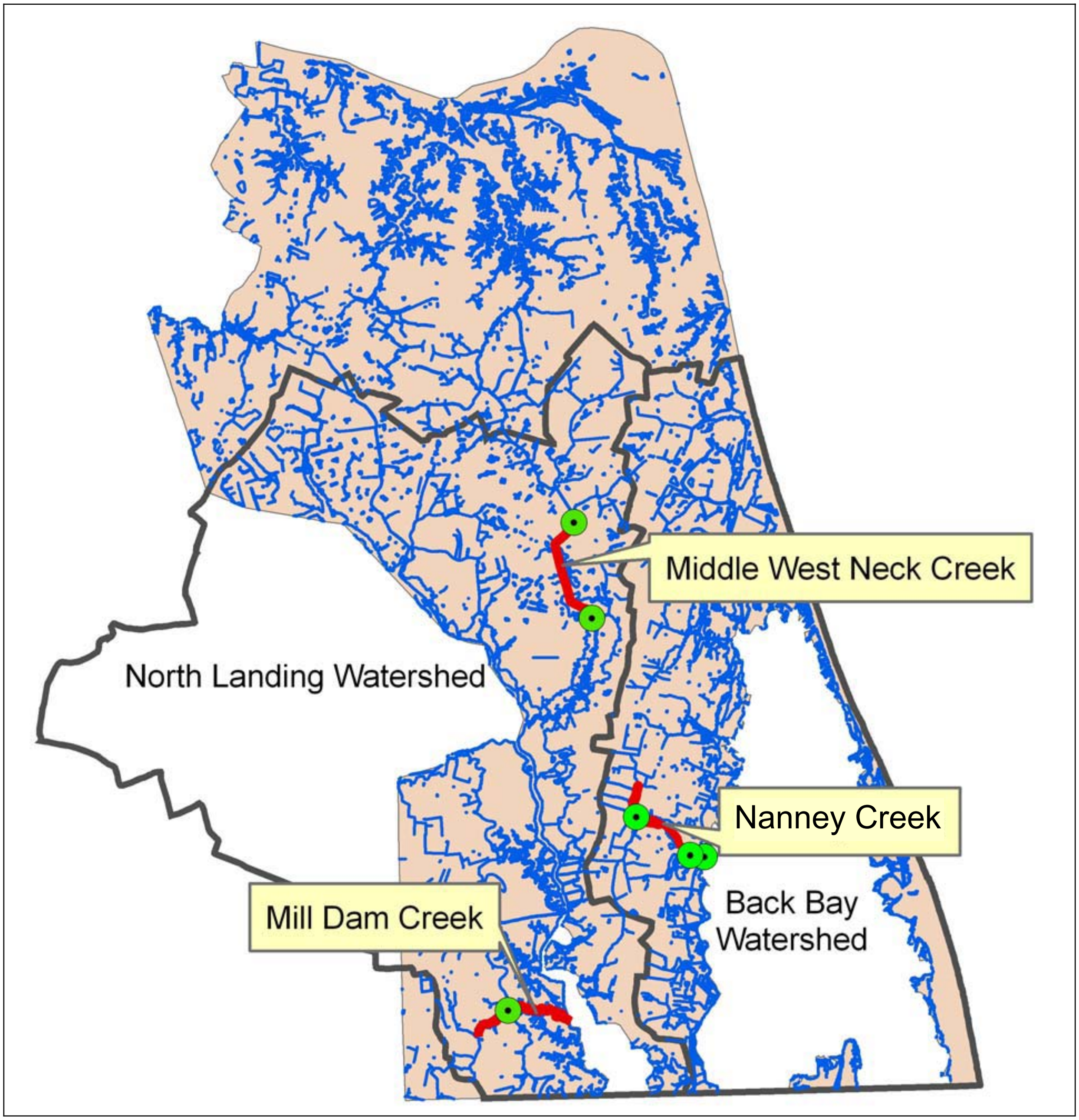


Figure 4-3 Water Quality Monitoring Stations Maintained by DEQ

Table 4-4 Water Quality Data Summary (DEQ 2004)

Stream Name	Station Id	Sampled Dates	#	Parameter Name	Minimum	Maximum	Mean	Median
Milldam Creek	5BMLD001.92	9/95-3/04	83	Fecal coliform	49	8,000	406	100
		7/02-3/04	10	*E. coli*	10	620	184	75
Nanney Creek (mouth)	5BNWN000.00	6/93-3/04	100	Fecal coliform	25	4,700	589	200
		7/02-3/04	10	*E. coli*	10	750	159	60
		7/02-9/04	14	*enterococci*	10	2,000	278	55
Nanney Creek (upper)	5BNWN001.84	6/93-3/04	100	Fecal coliform	25	2,900	528	210
		7/02-3/04	9	*E. coli*	10	420	139	90
West Neck Creek (Middle)	5BWNC003.65	6/91-5/04	103	Fecal coliform	25	4,200	307	100
		7/02-5/04	11	*E. coli*	10	800	134	50
West Neck Creek (Middle)	5BWNC006.64	6/72-5/79	70	Fecal coliform	19	8,000	953	105

Table 4-5 Summary of bacterial source tracking results from water samples collected in the Nanney Creek impairment.

Station	Date	Fecal Coliform (cfu/100 ml)	*E. coli* (cfu/100 ml)	Percent Isolates classified as: Wildlife	Human	Livestock	Pet
5BNWN000.00	7/14/2003	300	28	0%	0%	**100%**	0%
	8/11/2003	6,500	260	8%	0%	**88%**	4%
	10/20/2003	50	40	0%	0%	100%	0%
	11/17/2003	350	70	**33%**	0%	4%	**63%**
	12/8/2003	120	112	**46%**	**25%**	**29%**	0%
	1/12/2004	50	38	**63%**	**25%**	8%	4%
	2/9/2004	70	50	**21%**	0%	**79%**	0%
	3/15/2004	20	34	**70%**	10%	**15%**	5%
	4/12/2004	50	132	**12%**	**38%**	4%	**46%**
	5/10/2004	20	40	50%	50%	0%	0%
	6/14/2004	240	30	25%	0%	0%	75%

Table 4-6 Weighted Averages for BST Station

	Weighted Averages			
Station ID	**Wildlife**	**Human**	**Livestock**	**Pet**
5BNWN000.00	16%	6%	70%	8%
5BMLD001.92	23%	18%	39%	20%

4.4 Description of Water Quality Modeling

Allocation scenarios were modeled by MapTech, Inc. using a combination of HSPF and CE-QUAL-W2 water quality and pollutant loading models. Pollutant loadings under existing conditions were adjusted until the water quality standard was attained. The TMDLs developed for the Virginia Beach Coastal Area were based on the Virginia State Standard for *E. coli* and *enterococci*. According to the guidelines put forth by the VADEQ (VADEQ, 2003) for modeling *E. coli* with HSPF, the model was set up to estimate loads of fecal coliform, then the model output was converted to concentrations of *E. coli* through the use of the following equation (developed from a data set containing n-493 paired data points):

$$\log_2 (C_{ec}) = -0.0172 + 0.91905 * \log_2 (C_{fc})$$

where C_{ec} is the concentration of *E. coli* in cfu/100 ml, and C_{fc} is the concentration of fecal coliform in cfu/100 ml. Per the guidelines put forth by the VADEQ (VADEQ, 2004) for modeling *enterococci* with HSPF and CE-QUAL-W2, the model was set up to estimate loads of fecal coliform, then the model output was converted to concentrations of e*nterococci* through the use of the following equation (developed from a data set containing 800+ paired data points):

$$\log_2(C_{ent}) = 1.2375 + 0.59984 \cdot \log_2(C_{fc})$$

where C_{ent} is the concentration of *enterococci* in cfu/100 ml, and C_{fc} is the concentration of fecal coliform in cfu/100 ml.

Pollutant concentrations were modeled over the entire duration of a representative modeling period, and pollutant loads were adjusted until the standard was met. The development of the allocation scenario was an iterative process that required numerous runs with each followed by an assessment of source reduction against the water quality target.

4.5 Description of Sources Considered

Both point and nonpoint sources of bacteria were considered in the TMDL Study. Point source pollutant loads are discharged at a specific location from pipes, outfalls, and conveyance channels from municipal wastewater treatment plants, storm water outfalls, or industrial waste facilities. Point sources can also include pollutant loads contributed by tributaries to the main receiving water or river. In this study, storm water runoff that flows through the City of Virginia Beach's Municipal Separate Storm Sewer System (MS4) was considered to be a point source because discharges are regulated through a permitting system. No other point sources are present in the watershed. Nonpoint source pollutants originate from multiple sources over a relatively large area, and can be divided into source activities related to either land or water use including failing or malfunctioning septic tanks, traditional animal-keeping practices, forest practices, and urban and rural runoff.

4.5.1 Point Source Contributions

The entire City of Virginia Beach is covered by an MS4 permit. The City does not have any major stormwater outfalls in the Nanney Creek subwatershed, but the City does maintain roadside ditches in these areas. Discharges are regulated by the Virginia DCR through a Virginia Pollution Discharge Elimination System (VPDES) permit issued to the City of Virginia Beach. The TMDL Study did not establish a Waste Load Allocation (WLA) to the City's MS4 for bacteria. This is an oversight that is currently being corrected by DEQ. This document will be edited to include the calculated WLA as soon as it is completed.

4.5.2 Non-Point Source Contributions

Non-point source contributions to the bacterial levels in the Nanney Creek and Middle West Neck Creek system result from both anthropogenic and natural sources. Potential human activities which may contribute to the bacterial pollution include failing septic systems and their associated drain fields, sanitary discharges from moored or transiting vessels, improper pet waste disposal practices, and sheet flow runoff from lawns and urban areas. Natural sources include the abundance of migratory and resident species of birds along with the natural mammalian populations.

In the Back Bay Watershed, both urban and rural nonpoint sources of fecal coliform bacteria were considered. Sources include residential sewage treatment systems, land application of waste (livestock and biosolids), livestock, wildlife, and pets. Sources were identified and enumerated. MapTech collected samples of fecal coliform sources (*i.e.,* wildlife, livestock, pets, and human waste) and enumerated the density of fecal coliform bacteria to support the modeling process and to expand the database of known fecal coliform sources for purposes of bacterial source tracking. Where appropriate, spatial distribution of sources was also determined.

4.6 TMDL Load Reductions and Allocation Results

The Total Maximum Daily Load or total allowable load for a waterbody is composed of a waste load allocation (WLA), load allocation (LA), and margin of safety (MOS).

Total Allowable Load =

Waste Load Allocation (WLA) + 5%MOS + Load Allocation (LA)

Allocation scenarios were modeled using a combination of HSPF and CE-QUAL-W2. Pollutant loadings under existing conditions were adjusted until the water quality standard was attained. The TMDLs developed for the Virginia Beach Coastal Area were based on the Virginia State Standard for *E. coli* and *enterococci*. According to the guidelines put forth by the VADEQ (VADEQ, 2003) for modeling *E. coli* with HSPF, the model was set up to estimate loads of fecal coliform, then the model output was converted to concentrations of *E. coli.*

Pollutant concentrations were modeled over the entire duration of a representative modeling period, and pollutant loads were adjusted until the standard was met. The development of the allocation scenario was an iterative process that required numerous runs with each followed by an assessment of source reduction against the water quality target.

Table 4-7: Total Load Allocations

Impairment	TMDL Standard	WLA (cfu/year)	LA (cfu/year)	MOS	TMDL (cfu/year)
Nanney Creek	*enterococci*	0.00E+00[1]	5.09E+12		5.09E+12

[1] *A WLA for Virginia Beach's MS4 was not calculated during the original TMDL study. This was an oversight that will be corrected by DEQ in the near future.*

5.0 PUBLIC PARTICIPATION

An essential step in implementing a TMDL is the input from a broad range of individuals, agencies, organizations and businesses because of their interest and familiarity with local water quality needs and conditions. Public participation facilitates dialogue between local stakeholders and government agencies to commit resources to TMDL implementation, such as funding and technical support. Community members are best suited to identify and resolve sources of water quality problems. In order to engage the public in the development of the TMDL Implementation Plan for the Nanney Creek and Middle West Neck Creek subwatersheds, public meetings were held in May 2007 and the January of 2009. The City of Virginia Beach, other agencies, and community groups are pursuing a number of activities independently of the TMDL Implementation Plan Process. Where appropriate, these initiatives were incorporated into the TMDL Implementation Plan process.

A Technical Advisory Committee was established to guide development of the TMDL Implementation Plan. The TAC met quarterly to review background materials and draft elements of the implementation plan. The TAC was composed of representatives of city departments, landowners, and state and federal agencies.

- City of Virginia Beach – Departments of Planning, Public Works, Agriculture
- Hampton Roads Planning District Commission
- Virginia Department of Environmental Quality – Water Division
- Virginia Department of Conservation and Recreation –Soil and Water Conservation
- Virginia Department of Health
- Virginia Department of Game and Inland Fisheries
- Virginia Dare Soil and Water Conservation District
- Back Bay Restoration Foundation
- Back Bay National Wildlife Refuge

6.0 IMPLEMENTATION OPTIONS

Reduction strategies in the Nanney Creek subwatershed will be implemented in a phased process that first addresses sources with the largest impact on water quality. Phase I includes a watershed characterization to field verify conditions reported in the TMDL and to identify the potential sources of bacteria pollution. Phase I has been completed in the Nanney Creek Watershed.

6.1 Linking the TMDL to Implementation

The Virginia Beach Coastal Area TMDL was approved by EPA in 2005, but relied largely on national and state data collected prior to 2004. It is important to consider both the TMDL as well as the additional information obtained since its completion when developing the implementation actions that may improve water quality within the Nanney Creek subwatershed. It should be noted that due to uncertainty, the allocations contained in the TMDL study should, but may not, result in attainment of the bacteria standard for swimming in these watersheds. The success of the management actions proposed in this document will be determined by ambient water quality data rather than attainment of load allocations.

The TMDL Study utilized the National Land Cover Data (NLCD) to calculate the load allocations in the TMDL. This dataset was developed using aerial photography from 1990 and 1994. While the Nanney Creek subwatershed is located in the more rural section of Virginia Beach, there have been significant changes to the subwatershed in the last 14 years. Agricultural uses have shifted from animal production to crops, dominant crops have changed, and road networks have expanded, and some rural residential development has taken place. The citizens of the southern area of Virginia Beach were skeptical of a report using such outdated land cover data and other statistics and were reluctant to participate in the Implementation efforts. In an effort to gain community support for watershed cleanup activities, the City contracted with URS Corporation to complete a more in-depth study of land uses and potential bacteria sources in the Nanney Creek subwatershed. Results from this study are summarized below and additional maps and documents are included in Appendix A.

The City of Virginia Beach and its partners will utilize an adaptive management approach in the implementation of the management actions described within this report. These management actions discussed in detail in subsequent sections were chosen because it is believed they will have the greatest effect on improving water quality within the Nanney Creek subwatershed. As actions are implemented, water quality data are collected, and new information and technology become available, the City of Virginia Beach, in consultation with the Commonwealth, will discontinue actions that are deemed ineffective and add actions that may not be included in this report. The feasibility of attaining the water quality criterion for swimming must also be considered. Resources will first be focused on implementing management options in areas where they will have the greatest impact on water quality improvements.

6.2 Identifying Implementation Actions

The implementation actions discussed below were developed to reduce human, pet and livestock sources of bacteria loading to Nanney Creek. These actions will be implemented in three phases as identified in Table 6-1. Phase I actions will include a reexamination of the land use data and current sources contributing to the impairment of the waterbodies as well as a public information campaign to educate citizens in the watershed about water quality issues and how they can help reduce fecal coliform loadings to the waterbodies. Phase II activities are those that are planned for implementation within the next five years but may not have approved funding sources yet. Several Phase II activities were implemented during the development of this Implementation Plan, and these are identified in Table 6-1 by yellow highlighting. Phase III actions may require regulatory changes, but they can be implemented as necessary if Phase I and Phase II actions do not significantly improve water quality within the study area. Activities identified as ongoing are those that have already been implemented and are expected to continue regardless of the level of bacteria within the watersheds. If all these actions prove to be insufficient to meet the water quality criterion for swimming in Nanney Creek, then the designation of these waters for swimming may need to be further evaluated.

In order to remove a designated use or establish subcategories of a use, the state must demonstrate 1) that the use is not an existing use, 2) that downstream uses are protected, and 3) that the source of bacterial contamination is natural and uncontrollable by effluent limitations and by implementing cost-effective and reasonable best management practices for non-point source control (9 VAC 25-260-10). This and other information is collected through a special study called a Use Attainability Analysis (UAA). All site-specific criteria or designated use changes must be adopted as amendments to the water quality standards regulations. Watershed stakeholders and EPA will be able to provide comment during this process. Extensive follow-up monitoring, described in Section 7.3, will evaluate if the modeling assumptions were correct. If water quality standards are not being met, a UAA may be initiated to reflect the presence of naturally high bacteria levels due to uncontrollable sources.

Table 6-1 Management Options for Implementation of Bacteria TMDLs in the Back Bay Watershed

Management Category	Management Option	Development Phase
Agricultural BMPs	Equine Facility Inventory for Virginia Beach	Phase II
	Manure Management Assistance for Landowners	Phase II
	Soil and Water Conservation Programs	Ongoing
	Increase Lead Ditch Maintenance	Phase II
Stormwater Programs	Increase Cleaning and Maintaining Flow in Roadside Ditches	Phase II
	Conduct additional in-stream water quality sampling	Phase II
	Calculation of a WLA for the MS4	Phase I
Septic System Programs	Provide Information to Residents on Septic Tanks and Maintenance.	Phase II
	Provide Septic Tank Assistance to Homeowners	Phase II
Pet Waste Programs	Pet Waste Ordinance	Completed
Erosion and Sediment Control	Enforcement of Virginia Beach Erosion and Sediment Control Ordinance	Ongoing
Aquatic Resource Restoration	Riparian Buffer Enhancement Plan	Phase II
Education Programs	"Scoop the Poop" Program	Ongoing
	Watershed Markers	Ongoing
	Education for Livestock Owners	Ongoing
	Education for Equine Facility Owners	Phase II
	Stormwater Education programs in Schools	Ongoing
	Agriculture/Conservation Youth Programs	Ongoing
	BBRF Environmental Education Programs	Ongoing
Land Use Management	Wetlands and Waterfront Operations Program	Ongoing
	Clean Waters Task Force	Ongoing
	Floodplains Management	Ongoing
	Southern Watersheds Management Ordinance	Completed
	Implement Green Ribbon Committee Recommendations	Ongoing
Wildlife Contribution Controls	City Ordinance to Prevent Feeding of Waterfowl	Completed
	Evaluate/Inventory Wildlife Populations within the Watershed	Phase I
	Explore Introduction of Wildlife Management Programs	Phase II
	Increase penalty for wildlife dumping	Completed
Watershed Studies	Data Collection and Analysis in Nanney Creek Watershed	Phase I (completed)

6.2.1 Agricultural BMPs

DCR administers two programs through local Soil and Water Conservation Districts (SWCDs) to improve or maintain water quality in the state's streams, lakes, and bays through the installation or implementation of agricultural BMPs:

- The Virginia Agricultural BMP Cost-Share Program
- The Virginia BMP Tax Credit Program

Both programs offer financial and technical assistance as incentives to carry out construction or implementation of selected BMPs. Details on the BMPs that apply to both programs can be found in the Virginia Agricultural BMP Cost-Share Manual.

Funding varies by district. The state provides funds to the district for targeted priority hydrologic units. Areas with the greatest need, therefore, receive the greatest funding.

Assistance is available year-round to individuals willing to carry out an approved conservation plan. The business of farming requires as much planning and organization as any other. Strategies to protect surface and ground water should be in those plans. Many plans qualify, but all must be approved by the local district board to participate in some programs. Districts seek and recruit individuals whose efforts can make the greatest positive impact upon water quality.

6.2.1.1 The Agricultural BMP Cost-Share Program

The cost-share program supports using various practices in conservation planning to treat animal waste, cropland, pastureland, and forested land. Some are paid for at a straight per-acre rate. Others are cost-shared on a percentage basis up to 75 percent. In some cases, USDA also pays a percentage. In fact, the cost-share program's practices can often be funded by a combination of state and federal funds, reducing the landowner's expense to less than 30 percent of the total cost.

Because demand for cost-share assistance is great, districts support the implementation of only those plans which meet local water quality guidelines. Since all requests can't be satisfied, priority rankings of practices must be used to make sure money is distributed and spent wisely.

The most an individual may receive is $50,000. In any case, the state cost-share payment, combined with federal payements, will not exceed 75 percent of the total eligible costs.

Cost-share funds are also available for approved innovative BMP demonstration projects intended to improve water quality. Districts and individuals design the project and install and demonstrate the innovative technology or management system.

All practices in the program have been included because of their ability to improve or protect water quality. Many will also increase farm productivity by conserving soil and making wise use of farm resources.

6.2.1.2 The BMP Tax Credit Program

The Virginia Agricultural BMP Tax Credit Program, which began with the 1998 tax year, supports voluntary installation of BMPs that will address Virginia's nonpoint source pollution water quality objectives. Agricultural producers with an approved conservation plan can take a credit against state income tax of 25 percent of the first $70,000 spent on agricultural BMPs. The amount of tax credit cannot exceed $17,500 or the total state income tax obligation. Approved BMPs will be inspected by the district after installation. Soon after this certification, participants will receive cost-share payments or tax credit approval from their local SWCD.

6.2.2 Stormwater Programs

The TMDL Study calls for reductions in bacteria delivered to both waterbodies through urban stormwater runoff. In 1993, the City implemented a storm water management service fee for the purpose of maintaining and upgrading drainage systems within the City by addressing issues such as floodplain problems, improving drainage, and reducing pollutants in storm water runoff. Projects funded by this fee include the creation and cleaning of roadside ditches, pipe installations, street sweeping, spill clean-ups, and catch basin cleaning.

Traditional definitions of stormwater have usually characterized it as nonpoint source runoff. However, most urban and industrial stormwater is discharged through conveyances, such as separate storm sewers, ditches, channels or other conveyances, which are considered point sources under the Clean Water Act (CWA), and subject to regulation through the National Pollutant Discharge Elimination System (NPDES) permit program.

Virginia is an authorized state under the federal permitting program. DCR administers the federal program pertaining to the municipal separate storm sewer systems (MS4s) and construction activities as part of the Virginia Stormwater Management Program (VSMP) permit program, which is authorized under the Virginia Stormwater Management Act. As mandated by the Clean Water Act and EPA's Phase 1 (11/16/90) and Phase 2 (12/8/99) stormwater regulations, the federal permitting requirements have been incorporated into the Permit Regulation in sections 4 VAC50-60-380 and 390.

The Nanney Creek subwatershed is covered by a Phase I VPDES permit VA0088676 for the municipal separate storm sewer system (MS4) owned by the City of Virginia Beach. This permit was issued on January 6, 1996 and reissued in April 2001. The City has submitted an application for renewal of this permit. As of the completion of this report, the renewal process is ongoing. The existing Phase I VPDES permit for the City of Virginia Beach has been administratively continued.

The permit states, under Part II.A., that the "permittee" must develop, implement, and enforce a storm water management program designed to reduce the discharge of pollutants from the MS4 to the maximum extent practicable (MEP), to protect water quality, and to satisfy the appropriate water quality requirements of the Clean Water Act and the State Water Control Law." The permit also contains a TMDL clause that states: "If a TMDL is approved for any water body into which the MS4 discharges, the Board will review the TMDL to determine whether the TMDL includes requirements for control of storm water discharges." If discharges from the MS4 are not meeting the TMDL allocations, the Board will notify the permittee of that finding and may require that the Storm Water Management Program required in Part II be modified to implement the TMDL within a timeframe consistent with the TMDL." The City of Virginia Beach is currently involved in the reapplication process for its MS4 permit. The implementation actions listed below will be modified in order to comply with the terms of the new permit.

The TMDL Study did not include Waste Load Allocations (WLAs) to the City for the Nanney Creek subwatershed. This was an oversight that is currently being discussed with DEQ. The City operates and maintains the roadside ditches in this subwatershed. Bacteria can be washed off from the streets and transported through these ditches to the impaired waterbody. The City of Virginia Beach should receive an allocation for this bacterial contribution since it would be impossible for them to ensure that no bacteria reach the impaired waterbody through these ditches. The City will continue to clean and maintain flow in these ditches and will also explore establishing a monitoring program to evaluate the amount of bacteria being transported via the ditches to the impaired waterbody.

6.2.3 Pet Waste Programs

The TMDL Study called for reductions in bacteria from pets in residential areas. This reduction will be achieved primarily through public education campaigns discussed in 6.2.7. The City of Virginia Beach has an ordinance (#1237) that requires pet owners to clean up after their animals. Violation of this ordinance is a class 4 misdemeanor punishable by a maximum fine of $250.

6.2.4 Erosion and Sedimentation BMPs

Erosion and sedimentation control measures may indirectly reduce the bacteria loading to waterbodies. Bacteria can cling to small sediments, so erosion prevention measures should also serve to reduce bacteria loading. Historically, Virginia Beach's main generator of sediment pollution was from construction sites and other development, but shoreline erosion from ditches and creeks can also provide a significant source of sediment to the impaired waterbodies.

The Virginia Department of Conservation and Recreation (DCR) implements the state Erosion and Sediment Control (ESC) Program according to the Virginia Erosion and Sediment Control Law, Regulations, and Certification Regulations (VESCL&R). The law is codified at Title 10.1, Chapter 5, Article 4 of the Code of Virginia, regulations are found at Section 4VAC30-50, and certification regulations are found at Section 4VAC50-50 of the Virginia Administrative Code. The ESC Program's goal is to control soil erosion, sedimentation, and nonagricultural runoff from regulated "land-disturbing activities" to prevent degradation of property and natural resources. The regulations specify "Minimum Standards," which include criteria, techniques and policies that must be followed on all regulated activities. These statutes delineate the rights and responsibilities of governments that administer an ESC program and those of property owners who must comply.

DCR has created the Virginia Erosion and Sediment Control Handbook in order to establish minimum design and implementation standards to control erosion and sedimentation from land-disturbing activities in Virginia. Through the Virginia Beach Erosion and Sediment Control Ordinance, all construction in the City of Virginia Beach must conform to the minimum standards of the Virginia Erosion and Sediment Control Regulations and the Virginia Erosion and Sediment Control Handbook third edition. All construction related activities are to limit land disturbance to the amount necessary to accommodate the desired improvements. Work will be avoided in the tree drip line area and comply with the Virginia Erosion and Sediment Control Handbook with respect to tree preservation and protection. All contractors must have the current edition of the Virginia Erosion and Sediment Control Handbook available on-site.

6.2.5 Watershed Studies

In response to citizen concerns about the accuracy of the original TMDL Study, the City of Virginia Beach contracted with URS Corporation to develop a more detailed watershed model for the Nanney Creek subwatershed. URS Corporation gathered data to update the land use, drainage areas, septic tank, biosolids, livestock, pet, and wildlife inputs to the model. Site visits were conducted to gather land use information for parcels visible from public roads, and extensive efforts were made to gather information from citizens within the subwatershed. A public comment period was incorporated into each stage of model development. The data collected by URS and how it compared with the original data from the TMDL Study are summarized in below. Additional information on the model development is provided in Appendix A.

Table 6-1 Comparison of Water Quality Model Inputs

Bacteria Source	State Estimates	Watershed Study Estimate
Beaver	34	0
Deer	60	211
Ducks	38	43
Geese	14	256
Gulls	113	209
Muskrats	321	1601
Nutria	0	533
Youth	0	117
Adults	0	413
Raccoons	272	227
Cattle	0	8

Goats	0	154
Horses	15	275
Hogs	3727	609
Sheep	0	77
Dogs	141	431
Cats	158	0
Septic Tanks	260	352
Failing	40	35
Uncontrolled Discharges	4	unknown

6.2.6 Aquatic Resource Restoration

The goal of this implementation plan is to reduce fecal coliform bacteria concentrations to enable the safe primary contact recreation in these waterbodies. Restoration of riparian buffers will naturally reduce the transport of pollutants into the waterbodies. The City of Virginia Beach operates has developed a Riparian Buffer Enhancement Plan. This initiative encourages the preservation and restoration of critical shoreline habitats. Riparian forest buffers provide canopy shade and stream habitat, filter runoff, and uptake nutrients. The City will expand this program to the Southern Watersheds and continue to work with landowners to preserve and restore riparian buffers on their property.

6.2.7 Education Programs

Public education and outreach are important tools for reducing bacterial pollution due to pet waste, stormwater runoff, agricultural practices, and failing septic tanks. The Virginia Dare Soil and Water Conservation District, Back Bay Restoration Foundation and the 4H program conduct public education in the Nanney Creek subwatershed. Virginia Beach will continue to participate in regional education programs coordinated by the Hampton Roads Planning District Commission including HR WET, HR STORM, HR CLEAN, and HR FOG. Brief descriptions of these programs and their web addresses are displayed in Table 6-2.

The Virginia Beach SPCA has partnered with HR STORM to initiate a “Poop Pollutes” campaign to educate dog owners about the water pollution caused by pet waste. The campaign consists of posters, t-shirts, and a website to inform pet owners about the proper disposal of pet waste.

The Virginia Dare SWCD provides education and technical assistance on sediment, nutrient, and bacteria source reduction to landowners in the Nanney Neck Creek subwatershed. In the future, the SWCD will work with the City of Virginia Beach to implement an education program for equine facility owners within the City.

Although the first phases of the implementation plan do not directly address bacteria attributed to wildlife, there are a few management actions that can be implemented to reduce human causes of increased wildlife populations. A wildlife feeding education program will be initiated to discourage residents from feeding waterfowl. The feeding of waterfowl can cause local populations to increase and discourage migration in Giant Canada Geese. In addition to the education program, the City has developed an ordinance to prevent the feeding of waterfowl.

Table 6-2: Regional Education Programs in Hampton Roads

Regional Education Program	Description of Program	Program Web Address
HR CLEAN	HR CLEAN educates the region on the techniques of recycling, waste minimization, and the benefits of beautification and litter prevention.	www.hrclean.org
HR FOG	HR FOG educates the region on the proper techniques for disposing of oils and grease. The primary audience will be restaurants and homeowners will be a secondary audience.	Not yet established
HR STORM	HR STORM educates the region on the techniques of litter prevention, and the need to keep our storm water clean for the health of area waterways.	www.hrstorm.org
HR WET	The Hampton Roads Water Efficiency Team educates the region on the techniques of water conservation, raising public awareness of the region's water supplies, and promotes efficiency of water use.	www.hrwet.org

6.2.8 Land Use Management

The City of Virginia Beach has several programs that serve to manage development and minimize its environmental impact. Continuation of these programs will serve to protect critical habitats within the watersheds and may be important in reducing the amount of bacteria entering Nanney Creek.

In an effort to protect and enhance water quality in the Back Bay and North Landing River Watersheds, the Cities of Virginia Beach and Chesapeake and the Virginia Dare Soil and Water Conservation District are working together to identify water quality issues and address needs and problems within the Southern Watersheds Area. Under the direction of the Hampton Roads Planning District Commission, this group is currently working on a cooperative environmental management plan called SWAMP - the Southern Watersheds Area Management Program. The group's mission is to protect and enhance natural resources, sensitive lands, and water supplies of the Southern Watersheds of Virginia Beach and Chesapeake.

In addition to the regional management effort (SWAMP), the City of Virginia Beach has its own Southern Watersheds Management Ordinance (Appendix B) focused on protecting, enhancing, and restoring the waters within this area. The Ordinance includes provisions to protect environmentally sensitive lands adjacent to waters and wetlands, treat stormwater runoff, and restore riparian areas adjacent to waterways.

6.2.9 Wildlife Contribution Controls

The TMDL Study and subsequent work by URS suggest that wildlife contributions to Nanney Creek are significant. As discussed in previous sections, the focus of this implementation plan is to reduce anthropogenic sources of bacteria. However, the City of Virginia Beach will commence a study to determine if there is an overpopulation of deer within the Southern portion of the City, and will work with the residents and the Back Bay Wildlife Refuge to develop a management program.

6.3 Implementation Costs and Benefits

The primary benefit of the implementation of the management actions described in this IP is the reduction of bacteria levels in Nanney Creek. The programs and actions contained within this IP will serve to reduce the anthropogenic sources of bacteria within these watersheds. Because many of the programs mentioned in this report also serve purposes other than to reduce bacteria, and some cover areas larger than these three watersheds, the costs of reducing bacteria levels can be difficult to estimate. Estimated costs for proposed management actions and programs are outlined in Table 6-3.

Table 6-3: Estimated Costs of Management Options

Management Category	Management Option	Estimated Initial Costs[1]	Estimated Annual Maintenance Costs[1]
Agricultural BMPs	Equine Facility Inventory for Virginia Beach	**$20,000**	
	Manure Management Assistance for Landowners	**$20,000**	**$20,000**
	Soil and Water Conservation Programs	**$125,000**	**$110,000**
	Lead Ditch Maintenance	**$1,000,000**	**$150,000**
Stormwater Programs	Cleaning and Maintaining Flow in Roadside Ditches	**$1,500,000**	**$175,000**
	Conduct additional in-stream water quality sampling	**$100,000**	**$100,000**
	Calculation of a WLA for the MS4	**$10,000**	**$0**
Septic System Programs	Provide Information to Residents on Septic Tanks and Maintenance.	**$5,000**	**$5,000**
	Provide Septic Tank Assistance to Homeowners	**$50,000**	**$50,000**
Pet Waste Programs	Pet Waste Ordinance	**$2,500**	**$2,500**
Erosion and Sediment Control	Enforcement of Virginia Beach Erosion and Sediment Control Ordinance	**$25,000**	**$25,000**
Aquatic Resource Restoration	Riparian Buffer Enhancement Plan	**$100,000**	**$25,000**
Education Programs	"Scoop the Poop" Program	**$75,000**	
	Watershed Markers		
	Education for Livestock Owners		
	Education for Equine Facility Owners		
	Stormwater Education programs in Schools		
	Agriculture/Conservation Youth Programs		
	BBRF Environmental Education Programs		
Land Use Management	Wetlands and Waterfront Operations Program	**$10,000**	**$50,000**
	Clean Waters Task Force		
	Floodplains Management		
	Southern Watersheds Management Ordinance		
	Implement Green Ribbon Committee Recommendations		
Wildlife Contribution Controls	City Ordinance to Prevent Feeding of Waterfowl	**$150,000**	**$50,000**
	Evaluate/Inventory Wildlife Populations within the Watershed		
	Explore Introduction of Wildlife Management Programs		
	Increase penalty for wildlife dumping		
Watershed Studies	Data Collection and Analysis in the Nanney Creek subwatershed	**$100,000**	

[1] *City of Virginia Beach staff estimated costs for management categories using knowledge of current program costs and best professional judgment.*

7.0 MEASURABLE GOALS AND MILESTONES

7.1 Establishing Goals

7.1.1 TMDL Goals

- Reduce fecal bacteria load in order to meet the Total Maximum Daily Load and established water quality standards to the maximum extent economically achievable.

7.1.2 Related Watershed Management Goals

7.2 Establishing a Timeline and Milestones for Implementation

As described in previous sections, the actions proposed in this implementation will be implemented in phases. Phase I actions included additional data collection to update inputs to the Nanney Creek subwatershed model. This phase has been completed. A schedule of Phase II activities is contained in Table 7-1, and Phase III actions will be implemented as actions prove necessary and funding becomes available. The completion of management actions will be tracked in program annual reports. Management actions related to stormwater management will be reported in the City of Virginia Beach's MS4 annual report.

Table 7-1 Timeline for Phase II and Ongoing Management Actions

Management Category	Management Option	Projected Start Date	Projected Completion Date
Agricultural BMPs	Soil and Water Conservation Programs	Ongoing	Ongoing
	Lead Ditch Maintenance	Ongoing	Ongoing
	Manure Management Assistance for Landowners	January 2010	Ongoing
	Equine Facility Inventory for Virginia Beach	January 2010	Ongoing
Stormwater Programs	Cleaning and Maintaining Flow in Roadside Ditches	Ongoing	Ongoing
	Calculation of a WLA for the MS4	Ongoing	July 2009
	Conduct additional in-stream water quality sampling	September 2009	September 2010
Septic System Programs	Provide Information to Residents on Septic Tanks and Maintenance.	July 2009	Ongoing
	Provide Septic Tank Assistance to Homeowners	July 2009	Ongoing
Pet Waste Programs	Pet Waste Ordinance	Completed	
Erosion and Sediment Control	Enforcement of Virginia Beach Erosion and Sediment Control Ordinance	Ongoing	Ongoing
Aquatic Resource Restoration	Riparian Buffer Enhancement Plan	January 2010	Ongoing
Education Programs	"Scoop the Poop" Program	Ongoing	Ongoing
	Watershed Markers	Ongoing	Ongoing
	Education for Livestock Owners	Ongoing	Ongoing
	Education for Equine Facility Owners	January 2010	Ongoing
	Stormwater Education programs in Schools	Ongoing	Ongoing
	Agriculture/Conservation Youth Programs	Ongoing	Ongoing
	BBRF Environmental Education Programs	Ongoing	Ongoing
Land Use Management	Wetlands and Waterfront Operations Program	Ongoing	Ongoing
	Clean Waters Task Force	Ongoing	Ongoing
	Floodplains Management	Ongoing	Ongoing
	Southern Watersheds Management Ordinance	Completed	
	Implement Green Ribbon Committee Recommendations	Ongoing	Ongoing
Wildlife Contribution Controls	City Ordinance to Prevent Feeding of Waterfowl	Completed	
	Evaluate/Inventory Wildlife Populations within the Watershed	January 2010	January 2011
	Explore Introduction of Wildlife Management Programs	July 2011	July 2012
	Increase penalty for wildlife dumping	Completed	
Watershed Studies	Data Collection and Analysis in Nanney Creek Watershed	Completed	

7.3 Developing Tracking and Monitoring Plans

Data collection and analysis of bacteria at the two stations in Nanney Creek and additional stations within Back Bay will continue to be performed by DEQ and the Back Bay Restoration Foundation (Figure 7-1). The City of Virginia Beach will establish a monitoring program to evaluate the amount of bacteria being transported via City maintained roadside ditches to Nanney Creek. This monitoring plan is currently being developed and will be implemented as a one year pilot study beginning in September 2009.

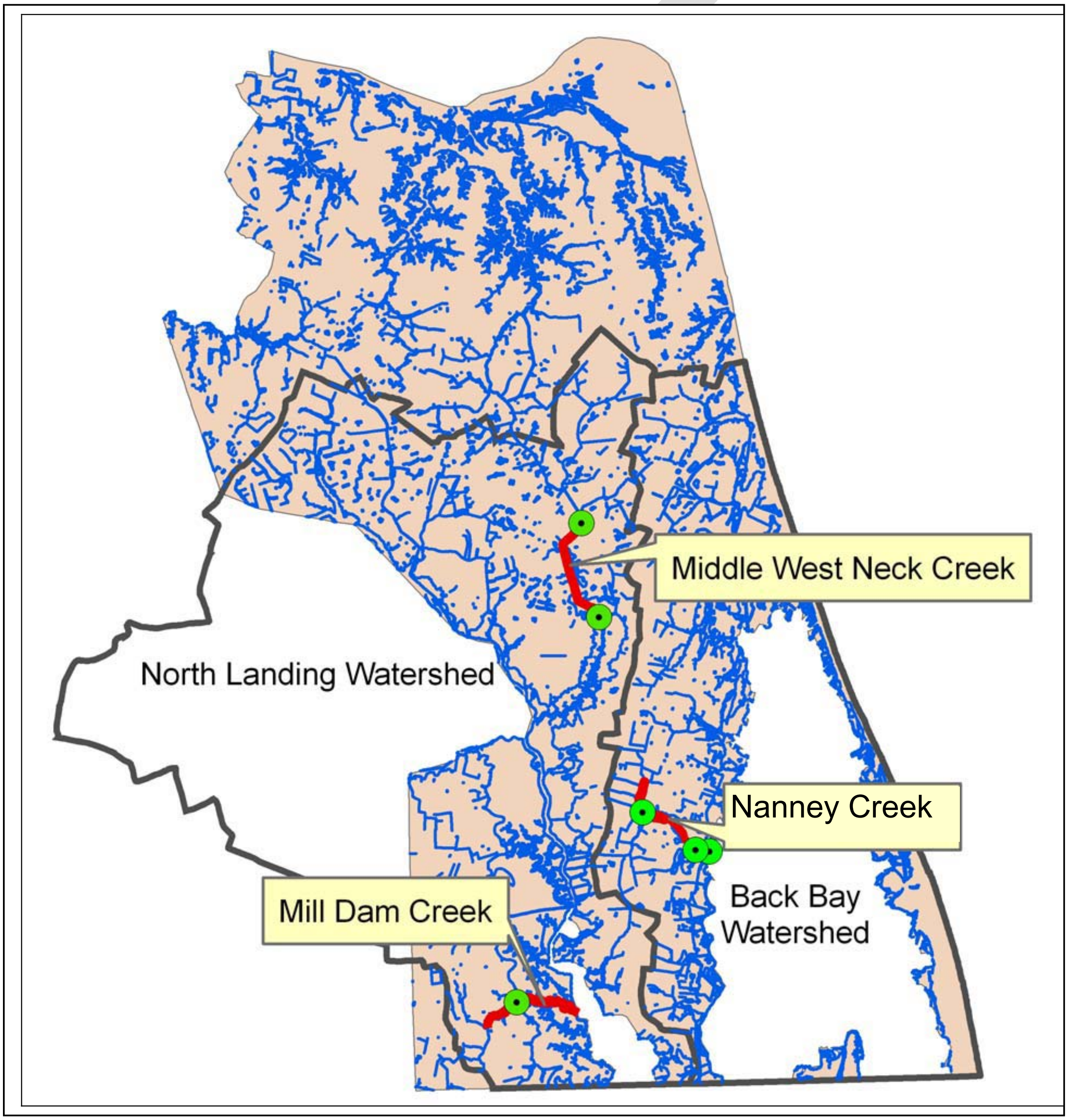


Figure 7-1 Water Quality Monitoring Stations Maintained by DEQ.

8.0 STAKEHOLDERS ROLES AND RESPONSIBILITIES

The management actions described in this report will be implemented by federal, state, regional and local agencies and non-governmental organizations in a collaborative effort to achieve the primary goal of reducing fecal coliform concentrations within the Nanney Creek subwatershed. The following section describes the agencies involved in the development of this Implementation Plan. Table 8-1 summarizes the roles and responsibilities of each agency by indicating for which management actions each agency is responsible.

8.1 Federal

8.1.1 United States Environmental Protection Agency

Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for water bodies which are exceeding water quality standards. The EPA has the regulatory authority to approve TMDLs. Section 303(d) of the CWA and current EPA regulations do not require the development of implementation strategies. The EPA will review the Nanney Creek Implementation Plan for completeness.

8.1.2 United States Fish and Wildlife Service

The federal facilities pollution control law (33USC1323) quoted below regulates the discharge of pollutants from federal properties.

" (a) Each department, agency, or instrumentality of the executive, legislative, and judicial branches of the Federal Government (1) having jurisdiction over any property or facility, or (2) engaged in any activity resulting, or which may result, in the discharge or runoff of pollutants, and each officer, agent, or employee thereof in the performance of his official duties, shall be subject to, and comply with, all Federal, State, interstate, and local requirements, administrative authority, and process and sanctions respecting the control and abatement of water pollution in the same manner, and to the same extent as any nongovernmental entity including the payment of reasonable service charges. The preceding sentence shall apply (A) to any requirement whether substantive or procedural (including any recordkeeping or reporting requirement, any requirement respecting permits and any other requirement, whatsoever), (B) to the exercise of any Federal, State, or local administrative authority, and (C) to any process and sanction, whether enforced in Federal, State, or local courts or in any other manner. This subsection shall apply notwithstanding any immunity of such agencies, officers, agents, or employees under any law or rule of law."

8.2 State

8.2.1 Department of Environmental Quality (DEQ)

The State Water Control Law authorizes the State Water Control Board to control and plan for the reduction of pollutants impacting the chemical and biological quality of the State's waters resulting in the degradation of the swimming, fishing, shell fishing, aquatic life, and drinking water uses. For many years the focus of DEQ's pollution reduction efforts was the treated effluent discharged into Virginia's waters via the VPDES permit process. The TMDL process has expanded the focus of DEQ's pollution reduction efforts from the effluent of wastewater treatment plants to the pollutants causing impairments of the streams, lakes, and estuaries. The reduction tools are being expanded beyond the permit process to include a variety of voluntary strategies and BMPs.

The DEQ is the lead agency in the TMDL process. The Code of Virginia directs DEQ to develop a list of impaired waters (303 (d) list), develop TMDLs for these waters, and develop Implementation Plans for the TMDLs. DEQ administers the TMDL process including the public participation component and formally submits the TMDLs to EPA and the State Water Control Board for review and approval.

Additionally, §303(e) of the Clean Water Act and EPA's water quality management regulation 40 CFR 130.5 requires the States to develop Water Quality Management Plans (WQMP) for the major watersheds. The purpose of the WQMPs is to present the processes to be used in the watershed for attaining and maintaining water quality standards. Also, the WQMPs serve as the repository for all TMDLs and TMDL Implementation Plans developed within the watershed. DEQ, with the assistance of DCR, the Department of Mines, Minerals and Energy (DMME), and VDH plans to update the State's 303(e) WQMPs concurrently with the TMDL development effort.

8.2.2 Department of Conservation and Recreation (DCR)

DCR is authorized to administer Virginia's nonpoint source pollution reduction programs in accordance with §10.1-104.1 of the Code of Virginia and §319 of the Clean Water Act. EPA is requiring that much of the §319 grant monies be used for the development of TMDLs.

Because of the magnitude of the nonpoint source component in the TMDL process, DCR is a major participant in the TMDL process. DEQ and DCR have signed a Memorandum of Understanding agreeing to a cooperative effort in the TMDL process including Implementation Plan development. Specifically, DCR agreed to assume responsibility for the nonpoint source component of all TMDLs including the final allocations, with the exception of mineral extraction. This includes those TMDLs contracted by DEQ. Also, DCR agreed to present the nonpoint source component of the TMDLs in the public forums. Another major role DCR has in the TMDL process is the awarding and managing of the contractual services for the development of TMDLs related to nonpoint sources.

8.2.3 Soil and Water Conservation District

The Virginia Dare Soil and Water Conservation (SWCD) is one of 47 districts in Virginia. Districts are subdivisions of state government which coordinate local natural resource protection programs (section 10.1-50 of the code of VA, 1950, as amended). A Board of Directors consists of four elected and two appointed members to govern the district. The Virginia Dare SWCD provides local leadership in conservation of soil, water, and related natural resources in the cities of Virginia Beach and Chesapeake. Some programs available through the district include: cost-share assistance to agricultural producers who install conservation practices on their farms as well as a wide variety of educational programs that cater to school children and local organizations.

8.2.4 Department of Game of Inland Fisheries

The Virginia Department of Game and Inland Fisheries' mission is to manage Virginia's wildlife and inland fish to maintain optimum populations of all species to serve the needs of the Commonwealth; to provide opportunity for all to enjoy wildlife, inland fish, boating and related outdoor recreation; to promote safety for persons and property in connection with boating, hunting and fishing.

8.3 Regional

8.3.1 Hampton Roads Planning District Commission

Planning District Commissions are voluntary associations that were created in 1969 pursuant to the Virginia Area Development Act and a regionally executed Charter Agreement. The purpose of planning district commissions, as set out in the Code of Virginia, Section 15.2-4207 is "…to encourage and facilitate local government cooperation and state-local cooperation in addressing on a regional basis problems of greater than local significance."

The Hampton Roads Planning District Commission (HRPDC), one of 21 Planning District Commissions in the Commonwealth of Virginia, is a regional organization comprised of this area's sixteen local governments. The HRPDC was formed in 1990 by the merger of the Southeastern Virginia Planning District Commission and the Peninsula Planning District Commission. The HRPDC serves as a resource of technical expertise to its member local governments. It provides assistance on local and regional issues pertaining to Economics, Physical and Environmental Planning, and Transportation. As a Virginia Planning District, the HRPDC is also the Affiliate Data Center for the region, providing economic, environmental, transportation, census, and other relevant information to businesses, organizations and citizens.

The HRPDC was contracted by the Virginia DEQ and the City of Virginia Beach to develop this Implementation Plan for the bacteria TMDL subwatersheds in the Back Bay Watershed. In addition to facilitating the implementation process and developing this report, the HRPDC will continue to 1) facilitate regional cooperation in stormwater and wastewater management, 2) continue to administer regional education programs, and 3) develop a protocol for future TMDL Implementation Plan development within Hampton Roads.

8.4 City of Virginia Beach

As discussed throughout this document, the City of Virginia Beach has the largest role in improving water quality within Nanney, Creek. The City will continue public programs to treat stormwater runoff, and manage land use development to the maximum extent practicable and as required by law. Specific actions that the City of Virginia Beach will implement in order to reduce bacteria concentrations within these watersheds are outlined in Table 6-1.

8.5 Private Sector, Non-governmental, and Citizen Groups

8.5.1 Back Bay Restoration Foundation

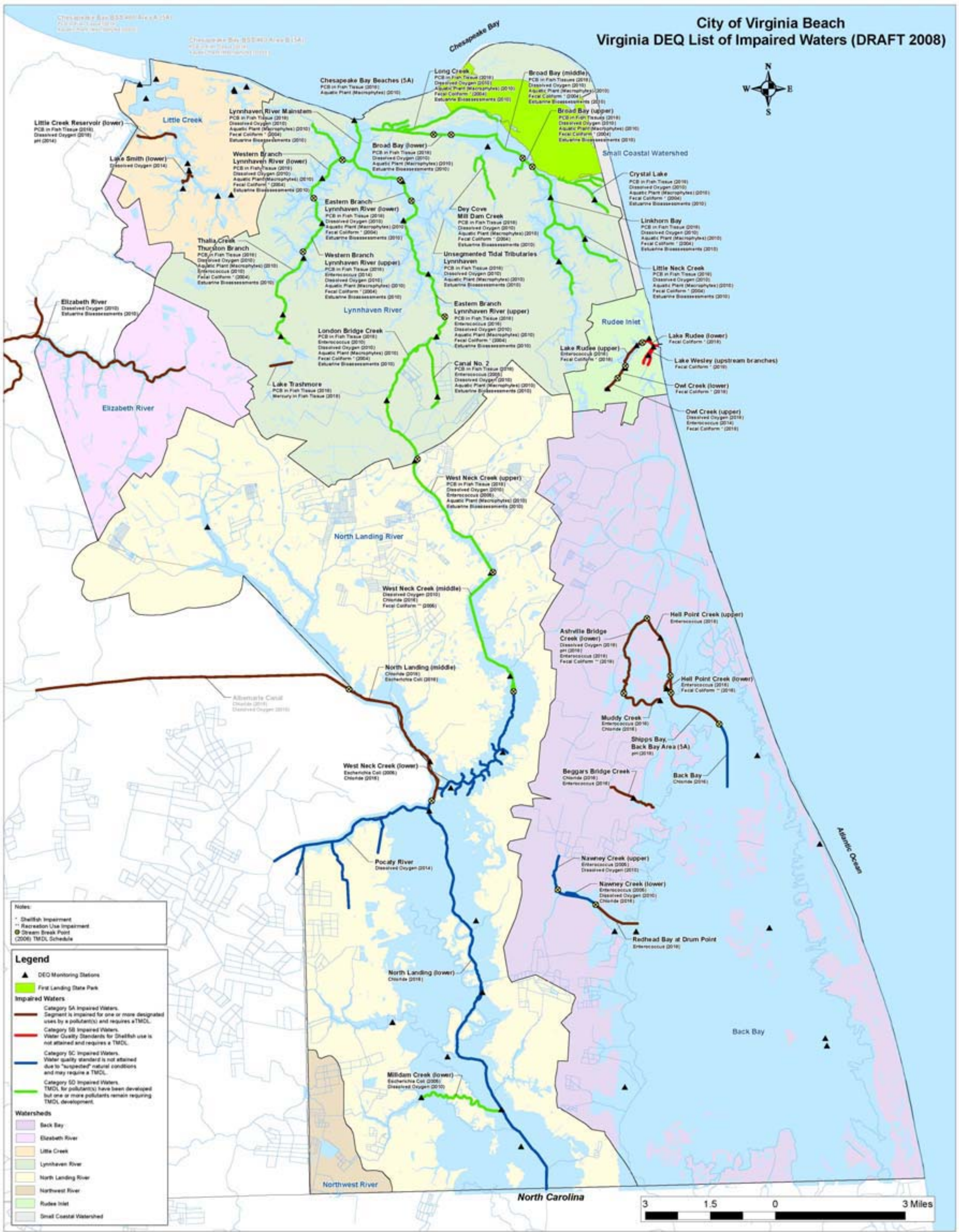
The Back Bay Restoration Foundation, Ltd. ("BBRF") is a non-profit organization founded in 1984 to address the deteriorating water quality of Back Bay. Under the leadership of an eleven member Board of Directors, BBRF established a successful program of cooperation and coordination of its activities with local, state and federal governmental and private organizations. Membership is rising and currently stands at approximately fourteen hundred (1,400) members. Since its inception, one of the primary activities of BBRF has been water quality monitoring. Now, bi- monthly, at six (6) selected sites along the western shore of Back Bay, measurements are taken and samples obtained. These samples are sent to the Virginia Department of Environmental Quality lab in Richmond where tests are performed for several criteria. Though samples are only lab-analyzed bi-monthly, testing is performed every month on the core parameters. Preservation, enhancement and improvement of the water quality and wetlands located in the Back Bay and North Landing River watersheds has become BBRF's expanded focus.

Table 8-1: Management Actions and Responsible Stakeholders

Management Category	Management Option	Stakeholders Responsible
Agricultural BMPs	Lead Ditch Maintenance	City of Virginia Beach
	Soil and Water Conservation Programs	VA Dare Soil and Water Conservation District (SWCD)
	Manure Management Assistance for Landowners	
	Equine Facility Inventory for Virginia Beach	
Stormwater Programs	Cleaning and Maintaining Flow in Roadside Ditches	City of Virginia Beach
	Calculation of a WLA for the MS4	VA DEQ
	Conduct additional in-stream water quality sampling	City of Virginia Beach
Septic System Programs	Provide Information to Residents on Septic Tanks and Maintenance.	City of Virginia Beach
	Provide Septic Tank Assistance to Homeowners	City/DCR
Pet Waste Programs	Pet Waste Ordinance	City of Virginia Beach
Erosion and Sediment Control	Enforcement of Virginia Beach Erosion and Sediment Control Ordinance	City of Virginia Beach
Aquatic Resource Restoration	Riparian Buffer Enhancement Plan	City of Virginia Beach
Education Programs	"Scoop the Poop" Program	City of Virginia Beach
	Watershed Markers	
	Education for Livestock Owners	City of Virginia Beach/ VA Dare SWCD
	Education for Equine Facility Owners	
	Stormwater Education programs in Schools	
	Agriculture/Conservation Youth Programs	City / VA Dare SWCD/Virginia Coop Extension
	Environmental Education Programs	City / VA Dare SWCD/ BBRF
Land Use Management	Wetlands and Waterfront Operations Program	City of Virginia Beach
	Clean Waters Task Force	
	Floodplains Management	
	Southern Watersheds Management Ordinance	
	Implement Green Ribbon Committee Recommendations	
Wildlife Contribution Controls	City Ordinance to Prevent Feeding of Waterfowl	City of Virginia Beach
	Evaluate/Inventory Wildlife Populations within the Watershed	
	Explore Introduction of Wildlife Management Programs	
Watershed Studies	Data Collection and Analysis in Nanney Creek Watershed	City of Virginia Beach

9.0 RELATED WATERSHED PLANNING EFFORTS

9.1 Adjacent Impaired Waterbodies



10.0 POTENTIAL FUNDING SOURCES

State
Virginia Agricultural Best Management Practices
Cost-Share Program
Virginia Agricultural Best Management Practices
Tax Credit Program
Virginia Agricultural Best Management Practices
Loan Program
Virginia Forest Stewardship Program
Virginia Small Business Environmental Assistance Fund Loan Program
Virginia Resource Authority
Water Quality Improvement Fund
Clean Water Act Revolving Loan Program

Federal
EPA 319 Funds
USDA Conservation Reserve Program (CRP)
USDA Conservation Reserve Enhancement Program (CREP)
USDA Environmental Quality Incentives Program (EQIP)
USDA Forest Incentive Program (FIP)
USDA Watershed and River Basin Planning and Installation Public Law 83-566 (PL566)
USDA Wildlife Habitat Incentive Program (WHIP)
USDA Wetland Reserve Program (WRP)
US Fish and Wildlife Service Private Stewardship Program
US Fish and Wildlife Service Conservation Grants

Local or Regional
City of Virginia Beach
City of Virginia Beach Capital Improvement Program
Hampton Roads Environmental Education Program Mini-Grants

Landowner Contributions and Matching Funds
The Virginia and federal cost-share assistance programs require a cost-share match, which is generally 25%.

Private Foundations, Non-Profit Organizations, Businesses
National Fish and Wildlife Foundation

10.1 Requirements for Section 319 Fund Eligibility

EPA develops guidelines that describe the process and criteria to be used to award CWA Section 319 nonpoint source grants to States. The most recent guidance, “Nonpoint Source Program and Grants Guidelines for States and Territories,” was effective as of October 23, 2003, and identifies the following nine elements that must be included in the IP to meet the 319 requirements:

1. Identify the causes and sources or groups of similar sources that will need to be controlled to achieve the load reductions estimated in the watershed-based plan;
2. Estimate the load reductions expected to achieve water quality standards;
3. Describe the NPS management measures that will need to be implemented to achieve the identified load reductions;
4. Estimate the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement the watershed-based plan.
5. Provide an information/education component that will be used to enhance public understanding of the project and encourage the public's participation in selecting, designing, and implementing NPS management measures;
6. Provide a schedule for implementing the NPS management measures identified in the watershed based plan that is reasonably expeditious;
7. Describe interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented;
8. Identify a set of criteria for determining if loading reductions are being achieved and progress is being made towards attaining water quality standards, and if not, the criteria for determining if the watershed-based plan needs to be revised; and
9. Establish a monitoring component to evaluate the effectiveness of the implementation efforts

REFERENCES

Bales, Jerad D. and C. Skrobialowski. Flow and Salinity in West Neck Creek, Virginia, 1989-92, and Salinity in North Landing River, North Carolina, 1991-92. U.S. Geological Survey Water Resources Investigations Report 94-4067. 1994.

MapTech, Inc. Development of Bacterial TMDLs for the Virginia Beach Coastal Area (London Bridge Creek & Canal # 2, Milldam Creek, Nawney Creek, West Neck Creek (Middle), and West Neck Creek (Upper)). Blacksburg Virginia, 2005.

U.S. Environmental Protection Agency (EPA). Guidance for Water-Quality-based Decisions: The TMDL Process. 1991, EPA440-4-91-00.

Virginia Department of Conservation and Recreation and Virginia Department of Environmental Quality. Guidance Manual for Total Maximum Daily Load Implementation Plans. Richmond, Virginia. 2003.

Virginia Department of Environmental Quality (DEQ). 303(d) Total Maximum Daily Load Priority List and Report. 1998.

Appendix A:
Documentation of URS Corporation Watershed Study in the Nanney Creek Subwatershed

TECHNICAL MEMORANDUM
DRAINAGE PATTERN DETERMINATION & LAND USE DEVELOPMENT

Prepared for: City of Virginia Beach, Virginia
Department of Public Works

Prepared by: URS Corporation
Virginia Beach, Virginia

Date: Submitted December 6, 2007

Contract: PWCN-6-0026
Work Order 13A – Water Quality Model for Nanney Creek Basin
URS Project No. 11657119

PURPOSE

Violations of water quality criteria in portions of area streams led to the development of bacterial total maximum daily loads (TMDLs). Land use and drainage pattern determinations play a large part in the process and the results.

Concerns about the outdated, generic land use information used by the State to develop the bacterial TMDLs for sections of southern Virginia Beach have prompted the City to conduct similar studies – Nanney Creek being the first – to help guide implementation of management practices with the goal of improving water quality.

URS Corporation has been contracted by the City of Virginia Beach Department of Public Works to develop a watershed model for the Nanney Creek area. The main focus of this model is simulation of land-based fecal coliform loading and subsequent delivery to Nanney Creek. Public input is integral to accurate representation of current conditions in the study area. Therefore, a public comment period has been incorporated into each stage of model development. This Technical Memorandum (TM) addresses the processes by which drainage patterns and land use data were developed and updated for the modeling effort.

DRAINAGE PATTERN DETERMINATION

INTRODUCTION

The desired spatial resolution of data for the model required URS to delineate subwatersheds and subbasins for the Nanney Creek Basin, part of the Back Bay Watershed located in the southern portion of the City of Virginia Beach. Subbasins provide the finest resolution for the data. The links between subbasins are streams and outlet points. The Nanney Creek Basin (part of Watershed 24) boundary had previously been delineated and subdivided into subwatersheds to support earlier modeling efforts. Upon review, URS determined that it was more effective to adjust the existing basin and subwatershed boundaries and delineate new subbasin boundaries.

The BASINS 3.1 package being used to develop the Hydrologic Simulation Program – Fortran (HSPF) model for the Nanney Creek Basin provides several tools to delineate the study area: manual, automatic, and predefined. Based on the desired detail, the predefined approach was selected. The predefined delineation tool requires several data sets regarding the study area, including: subbasins, streams, and outlets.

PROCESS

URS started by looking at the basin and subwatershed boundaries. URS used contour, spot elevation, water body, and road information along with 2004 aerial photography provided by the City in August 2007 to revise the previously developed boundaries.

Few, if any, formal drainage structures are located within the study area. Therefore, URS conducted extensive field work in September 2007 to locate all drainage ditches visible from public roads and to determine a flow direction for the aforementioned ditches.

Field-observed ditch information as well as City-provided topographic data and aerial photography were used to delineate subbasins. To support the modeling effort it was determined that subbasins be approximately 30-40 acres in size. The resulting basin, subwatersheds, and subbasins were brought into the GIS.

Draft maps depicting the updated basin, subwatershed, and subbasin boundaries as well as the location and direction of observed ditches were posted for public comment for a period of a month (September 20, 2007 through October 20, 2007). The public was encouraged to make comments and suggest corrections to incorporate into the final drainage mapping. The City Agricultural Department and Virginia Dare Soil and Water Conservation District were also given a period of three (3) weeks (October 26, 2007 through November 16, 2007) to review and revise the draft mapping. Upon review of the provided comments and suggested revisions, the basin, subwatershed, and subbasin boundaries were finalized.

In addition to the subbasin boundaries, a stream network and outlet locations were required for modeling purposes. A stream, in this context, is simply the flow path though the subbasin. Using topographic information, field-gathered ditch information, City-supplied water body data, and best engineering judgment, the streams and outlet points were created by URS. Each subbasin has a corresponding stream and outlet point. The streams connect the subbasins to each other and ultimately connect the subbasins (land) to the water. Figure 1 depicts the final drainage network for the Nanney Creek Basin.

LAND USE DEVELOPMENT

INTRODUCTION

The Nanney Creek Basin is predominantly agricultural in nature. However, there are also several areas of low- to high-density residential and commercial land uses. The development of a basin-wide land use layer within the geographic information system (GIS) is important because it is used to accurately model precipitation-runoff relationships within the Basin.

PROCESS

Hard copy zoning maps for the study area were reviewed. From these zoning maps, several land use categories, as described below, were determined.

AG – Agricultural – zoning codes AG-1 and AG-2 were grouped.
SFL – Single Family Low Density – zoning code R-30.
SFH – Single Family High Density – zoning code R-5D.
O – Office – zoning code O-2.
B – Business – zoning code B-2.

However, these categories did not sufficiently capture the breadth of land use categories URS knew to be present. Additional categories were deemed necessary and these categories were derived from City-supplied data, field work, and a subsequent public comment period.

Using City-supplied aerial photography, parcel data, and water body information, URS developed the following additional categories.

BMP – Best Management Practice
CM – Cemetery
CH – Church
DR – Dirt Road
SFM – Single Family Medium Density
ST – Street – paved all roads.
WT – Wetland
WAT – Water
WD – Woods
UND – Undeveloped

Considering the agricultural nature of the Nanney Creek Basin, URS conducted field work in September 2007 to better determine the agricultural practices implemented for each of the parcels earlier identified as **AG** on the hard copy zoning maps. Several examples of the data gathered include the presence of a homestead, fields and associated crops, commercial agricultural buildings, and pastures. See Attachment A for a description of all land use data gathered as part of the field investigation.

The data gathered during the field investigations were input to GIS and depicted on large-scale draft land use maps. The draft maps were posted for public comment for a period of a month (September 20, 2007 through October 20, 2007). The scale of the maps (1” = 150’) was such that public participants were able to locate and provide comments and suggest corrections directly on their property to incorporate into the final land use determinations. Participants were also encouraged to complete a survey to document their involvement as well as provide information for incorporation into the next stage of model development – identification of bacterial sources. At the end of the public comment period, there were twelve (12) completed surveys. The City Agricultural Department and Virginia Dare Soil and Water Conservation District were also given a period of three (3) weeks (October 26, 2007 through November 16, 2007) to review and revise the draft mapping.

Upon review of the provided comments and suggested revisions, a comprehensive land use coverage was finalized (see Figure 2).

CONCLUSIONS

Land use and drainage pattern determinations play a large part in the watershed modeling process and impact the accuracy of the results. URS believes incorporating recent City-supplied data and field-observed data as well as the local knowledge provided by public comment into drainage pattern and land use determinations will benefit the overall study effort by providing updated, accurate information for use as input to the watershed model.

The document that was provided to the public as a guideline for the review process has been included as Attachment A.

LAND USE AND DRAINAGE MAP

GUIDE FOR REVISION

Thank you for coming out to share your knowledge of land use and drainage patterns in the watershed. These draft maps were developed based on observations made during site visits (from the street). Please feel free to use the provided red Sharpie markers to make any comments or corrections directly on the maps!

The following sections will introduce you to the types of data gathered.

When you have finished reviewing the maps, please take a minute to complete the provided survey.

Thank you for your time!

Drainage Map

Drainage ditches and flow direction were recorded during field visits. Please draw in any additional ditches that you are aware of and correct or provide flow direction for those already displayed.

Land Use Maps

Use the key map to locate your parcel on the larger maps. Please provide any additional information or make corrections to the information displayed for your land. Any place where you see Unknown, we were unable to make a determination.

Residential Properties

If we believe that your parcel is strictly residential, we ask that you verify the following:

1) The number of houses
2) Whether or not there is a pond
3) Is there a yard

Example from map:

Home: 1 (999 means unknown)

Pond: No (default value is No)

Yard: Yes

All Other Properties

For all other parcels, we ask that you verify the following:

1) The number of houses
2) Whether or not there is a pond
3) Type of agriculture: Field, Commercial (multiple buildings and/or silos) or Both
    a. Type of Field: Fallow, Crop, Orchard, Pasture, or Woods (We left space for more than one. List as many as are applicable.)
        i. Type of fall crop: Corn, Beans, Vegetable, Fruit, Grain, or Squash (We left space for more than one. List as many as are applicable.)
        ii. Type of spring crop: Currently listed as Unknown since site visits were recently completed. Please list one or multiple spring crops.
    b. Type of Building: Barn, Silo, or Stable (We left space for more than one. List as many as are applicable.)
    c. Type of animals: Dog, Horse, Goat, Cattle, or Hogs (We left space for more than one. List as many as are applicable.)
4) Is there a yard

Example from map:

Home: 0

Pond: Yes

Ag Type: Field

Field: Crop & Pasture

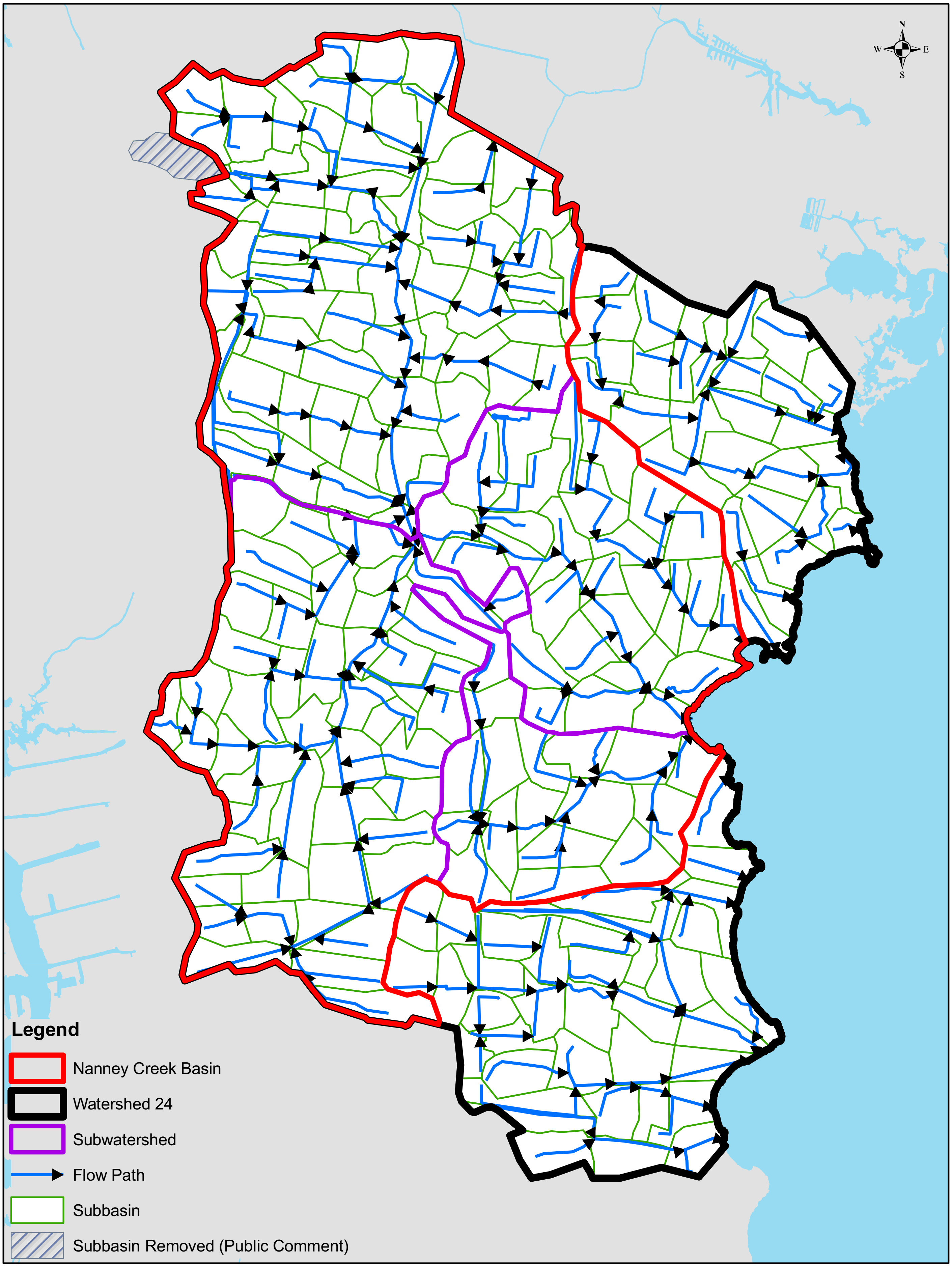
Fall: Beans & None (“None” in the second spot means there is only one crop.)

Spring: Unknown & Unknown

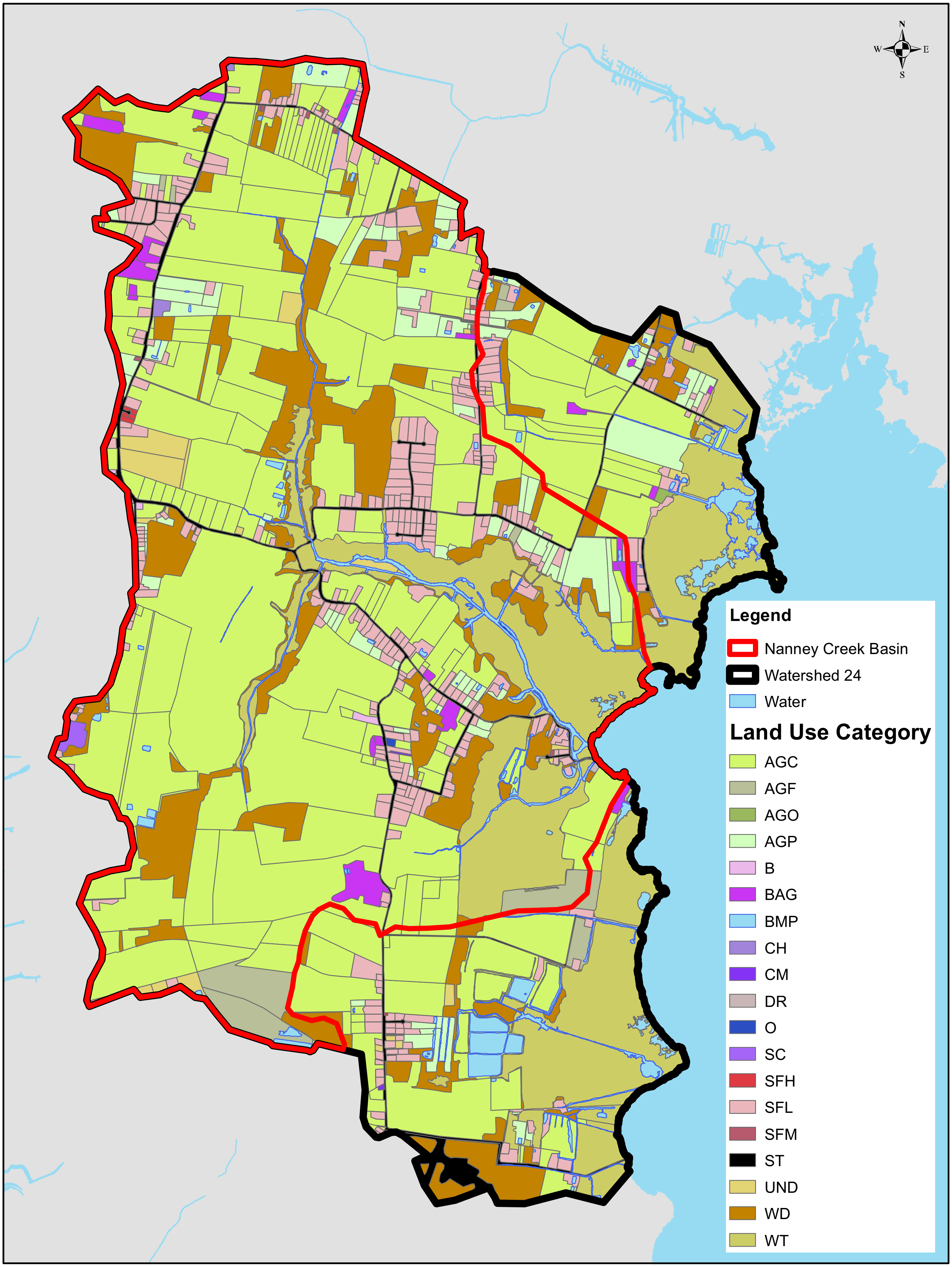
Building: Barn & Stable

Animals: Horses & Unknown

Yard: No



Watershed 24 (including Nanney Creek Basin)
Figure 1 Drainage Map



Watershed 24 (including Nanney Creek Basin)
Figure 2 Land Use Map

TECHNICAL MEMORANDUM
FECAL COLIFORM LOADING, REVISION 4

Prepared for: City of Virginia Beach, Virginia
Department of Public Works

Prepared by: URS Corporation
Virginia Beach, Virginia

Date: Resubmitted August 4, 2008
Previously Submitted April 15, 2008

Contract: PWCN-6-0026
Work Order 13A – Water Quality Model for Nanney Creek Basin
URS Project No. 11657119

PURPOSE

As a part of the water quality modeling effort for the Nanney Creek Basin, URS is simulating fecal coliform concentrations in surface runoff using the Hydrologic Simulation Program – Fortran (HSPF). This memorandum documents the process used to develop fecal coliform loads from the watershed and associated HSPF parameters.

SOURCE REPRESENTATION

Sources of fecal coliform to Nanney Creek were represented as either point or nonpoint sources in the model. All sources described below, with the exception of failing or malfunctioning septic systems, nutria, and muskrats, were simulated as land-based nonpoint sources. The fecal coliform bacteria were applied on land where a portion is available for transport in runoff. The rate of accumulation varies with landuse and season.

Septic tanks, nutria, and some muskrat contributions were represented as point source loads to the HSPF models. Therefore, the daily coliform load for each subbasin in the watershed was input as a time series (cfu/day) directly to each subbasin stream. Septic tank contributions also include flow time series (L/day) as input. Loads were applied in this manner for two reasons. (1) According to Virginia bacterial TMDL reports (MapTech, 2005), muskrats (and likewise nutria) deposit ninety percent (90%) of their waste directly to streams. (2) An HSPF land use segment must be greater than or equal to one (1) acre to be considered in the simulation. The nutria and muskrat habitat described later in this memorandum would have resulted in land segments smaller than one (1) acre had it been overlaid with the land use categories as described in the preceding paragraph. Septic systems are represented as point locations and therefore have no associated area.

SOURCE ASSESSMENT

The following sections address the sources of fecal coliform loading included in HSPF simulation. Habitat or application areas, as well as population densities, were developed through interviews performed by URS personnel, through field observations, and through literature review. Other data required to develop fecal load estimates include daily application rates and fecal coliform densities or concentrations for each source of fecal coliform pollution. While performing a literature review of bacterial TMDL and HSPF fecal coliform modeling reports, it became apparent that reported application rates and coliform densities / concentrations for the sources considered in this effort varied by several orders of magnitude (Vann et al., 2005) depending on the reference. It was determined that using values provided in the Virginia Beach Coastal Area Bacterial TMDL report (MapTech, 2005) would provide local, consistent data. Additional Virginia TMDL Reports and literature values were used for sources not referenced in the Virginia Beach Coastal Area Bacterial TMDL report. The following table provides the fecal coliform densities for all sources included in HSPF fecal coliform simulation.

Table 1. Daily Application Rates and Fecal Coliform Densities or Concentrations for Sources of Fecal Pollution in the Nanney Creek Basin (from MapTech, 2005 unless otherwise noted)

Source	Application Rate (g/animal-day)	FC Density (cfu/g)
Deer	772	380,000
Duck	150	3,500
Goose	225	250,000
Gull	19.9	120,000,000
Muskrat	100	1,900,000
Nutria – Adult	34.5 (Behaviors, 1998)	1,900,000 [C]
Nutria – Youth	9.7 (Behaviors, 1998)	
Raccoon	450	2,100,000
Cattle (Beef 800 lb)	21,046.7 [B] (MapTech, 2001)	45,500 (MapTech, 2001)
Goat	2,585.5 [B] (MapTech, 2001)	43,000 [D]
Hog (135 lb)	5125.6 [B]	400,000
Horse (1000 lb)	23,133.2 [B]	94,000
Sheep (60 lb)	1,088.6 [B]	43,000
Dog	450	480,000
Cat [A]	19.4	9
		FC Concentration (cfu/100mL)
Septic Tank Effluent	--	1,040,000

A. Values used are consistent with those in Virginia Beach Coastal Area Bacterial TMDL report (MapTech, 2005). The United States Environmental Protection Agency (USEPA, 2001) suggests a value of 5.0E+09 cfu/day cited from Horsely & Witten (1996).
B. Values originally reported as lb/animal-day.
C. Fecal coliform density for nutria feces was assumed to be equal to that of muskrat.
D. Fecal coliform density for goat feces was assumed to be equal to that reported for sheep – consistent with methodology used in development of Virginia TMDL reports.

WILDLIFE CONTRIBUTIONS

The wildlife species included in this survey can be found in significant numbers within the boundaries of the watershed, and include: deer, ducks, geese, gulls, muskrats, and nutria. Other species local to Nanney Creek, but not explicitly accounted for in this effort due to low populations, include bobcats, feral cats, foxes, and otters.

Wildlife populations for various species in the Nanney Creek Basin play an important role in water quality modeling, specifically in simulating fecal coliform loading to the watershed. Estimating species populations is difficult because wildlife populations are often surveyed at a larger geographic level, if at all. Wildlife population estimates for the Nanney Creek Basin were developed by interviewing biologists, conducting field observations, and collecting data from the Virginia Fish and Wildlife Information System (VAFWIS), Habitat Suitability Index Models released from the United States Fish and Wildlife Service (USFWS), the Virginia Department of Game and Inland Fisheries (VDGIF), and the United States Department of Agriculture (USDA) Fire Effects Information System (FEIS).

The first step in developing population estimates is to research individual species habitat. This aids in creating a spatial layer of probable high and low population habitat areas from which population estimates can be determined. The habitat for each wildlife species considered as a part of this effort, except for deer, geese, and gulls, depends heavily upon proximity to water. Defining each species' habitat was accomplished by researching available species information to see how far they range from water and creating a buffer of the appropriate distance around water bodies in the study area. Once habitat boundaries were established, population estimates were derived using documented population densities.

Deer

Through literature review and interviews, a deer population density of 15 per square mile was identified for areas of suitable habitat (VDGIF; Fairfax County, 2008). Suitable habitat consists of open fields near wooded areas. This estimate leads to a population of 60 deer in the Nanney Creek Basin. However, the residents of Nanney Creek believe that this figure significantly underestimates the actual deer population in the study area. Fairfax County, like Virginia Beach Watershed 24 (and Nanney Creek Basin), is a largely agricultural area bordered by a rapidly developing suburban landscape. The County performed a study that indicated as many as 400 deer per square mile can be found in the more rural parts of the county and up to 100 deer per square mile in urban sections (Fairfax County, 2008). In order to determine an appropriate deer population density for the study area, the initial model simulation will assume a density of 400 deer per square mile over the entirety of the study area. Resulting fecal coliform concentrations from this simulation will then be compared to available water quality observations. Adjustments to the deer population density will continue until reasonable agreement between model output and water quality observations has been obtained.

Table 2. Initial Deer Fecal Coliform Loads (cfu/acre-day)

Habitat	Initial Pop. Density (per square mile)	Pop. Density (per acre)	Waste Load (cfu/animal-day)	FC Load (cfu/acre-day)
Deer	400	0.625	2.93E+08	**1.83E+08**

Ducks

The Back Bay area has numerous water bodies, both natural and man-made, that provide suitable duck habitats. Mallard and Black – or dabbler – ducks are the most abundant species in the area (CBP & USFWSb). The primary habitat is within 150 feet of the shoreline (French and Parkhurst, 2001). Figure 1 depicts the primary and secondary habitats of ducks in the Nanney Creek Basin, corresponding to expected areas of high and low duck populations, respectively.

According to John Gallegos, chief biologist at the federal Back Bay refuge, duck populations at the refuge have declined rapidly since the 1960s from about 4,000 birds in 1961 to about 300 in 2006 (Harper, 2006). The Back Bay National Wildlife Refuge – which covers an area of 7732 acres (USFWSa) – is a good example of duck primary habitat. According to VDGIF, the latest survey yielded a population estimate of 2.6 ducks per square mile across Strata 3, the Mid-Atlantic region of the Atlantic Flyway Breeding Waterfowl Plot Survey that includes Virginia Beach. These figures were used to estimate the population density of duck secondary habitat.

Seasonal loads were developed for ducks. According to the Bird Checklist of the United States (USFWSb), Mallard and Black ducks are common from March to May (spring) and abundant from September through February (fall & winter). Therefore, the loads developed below, apply to all seasons with the exception of summer (June through August).

Due to land segment size limitations – minimum of one (1) acre – the duck primary habitat buffer was extended to coincide with the raccoon primary buffer. The population densities were adjusted accordingly.

Table 3. Development of Duck Fecal Coliform Loads (cfu/acre-day)

Habitat	Pop. Density (per square mile)	Pop. Density[A] (per acre)	Pop. Density[B] (per acre)	Waste Load (cfu/animal-day)	FC Load (cfu/acre-day)
Duck Primary	24.8	0.03880	0.01273	5.25E+05	**6.69E+03**
Duck Secondary	2.6	0.00406	0.00406	5.25E+05	**2.13E+03**

A. Population density based on original duck habitats as shown in Figure 2.
B. Population density adjusted for raccoon primary habitat and used to develop LC Load.
Calculated as $PrimaryDensity_{NEW} = (150ft*PrimaryDensity_{OLD} + 450ft*SecondaryDensity) / 600ft$

Geese

Snow and Canada geese are the most abundant species in the area (USFWSb). Both species have specialized bills for consuming agricultural plants, submerged aquatic vegetation (SAV), and other plants (CBP). Considering the goose diet, suitable goose habitat areas include croplands, undeveloped areas, and wetlands (Gallegos, 2008). See Figure 2 for a graphical depiction of goose habitat. According to VDGIF, the latest survey yielded a population estimate of 1.3 geese per square mile across Strata 3, the Mid-Atlantic region of the Atlantic Flyway Breeding Waterfowl Plot Survey that includes Virginia Beach. While populations of many waterfowl species have declined over the past few decades, Canada and Snow geese populations are increasing due to diet adaption (CBP). Field observations by VDGIF show that the average population for geese was approximately 44.2 per square mile for primary habitat areas. These observations were collected during the month of October.

Seasonal loads were developed for geese. According to the Bird Checklist of the United States, Snow and Canada geese are either common or abundant in all but the summer season. Therefore, the load developed below, applies to all seasons with the exception of summer (June through August).

Table 4. Development of Goose Fecal Coliform Loads (cfu/acre-day)

Habitat	Pop. Density (per square mile)	Pop. Density (per acre)	Waste Load (cfu/animal-day)	FC Load (cfu/acre-day)
Goose	44.2	0.06906	5.63E+07	**3.88E+06**

Gulls

Gull habitat was identified by J. Gallegos as cropland areas within the Nanney Creek Basin. While gulls are not known to be particularly selective when it comes to food, they have a preference for worms found in disturbed soils of agricultural fields (Gallegos, 2008). See Figure 3 for a graphical depiction of gull habitat. No source was available to estimate gull populations in the study area. Therefore, the assumption was made that the population density is similar to that of geese.

Seasonal loads were developed for gulls. The load developed below applies to the late winter and early spring seasons (January through March).

Table 5. Development of Gull Fecal Coliform Loads (cfu/acre-day)

Habitat	Pop. Density (per square mile)	Pop. Density (per acre)	Waste Load (cfu/animal-day)	FC Load (cfu/acre-day)
Gull	44.2	0.06906	2.39E+09	**1.65E+08**

Muskrats

Muskrats are abundant in the Tidewater area, and the Nanney Creek Basin is no exception. Muskrats do not stray far from water and are specific in their choice of water habitat. Low water velocities and heavy shoreline vegetation are preferred. Muskrats like marshes and small lakes and ponds as well as slow moving rivers (Allen & Hoffman, 1984). Steady water levels are preferred for their dens, with a moderately steep slope to the shoreline (USDA, 2005). According to local biologists, the optimal habitats for muskrats are areas of brackish streams, creeks, small freshwater lakes, and stormwater retention ponds (Herman, 2005).

However, populations of nutria (described in the following section) in the study area have forced the local muskrat population into a sub-optimal habitat situation. Nutria have taken over many muskrat dens, forcing the muskrats further inland. Muskrat habitat in the Nanney Creek Basin has been identified by area farmers (Salmons & Vaughan, 2008) as agricultural field drainage ditches; primarily fields closer to the creek and wetlands areas. Those areas previously identified as optimal muskrat habitat have been considered secondary habitat. Figure 4 depicts the primary and secondary habitats of muskrats in the Nanney Creek Basin, corresponding to expected areas of high and low muskrat populations, respectively.

Muskrat population densities are estimated at 1280 per square mile for low density, sub-optimal water habitat. Sixteen (16) muskrats per mile of agricultural field ditches would be expected under normal conditions (Fies, 2005). However, many muskrats have been forced to abandon optimal water habitats. Therefore, an increase in muskrat populations in agricultural field ditches directly bordering the creek and wetlands areas is expected – while populations further from the creek are expected to be lower than average. Ditch lengths per acre of field were determined using aerial imagery for a representative sample of fields within the study area. The median ditch length per acre of field included in the sample is 215 ft. This value has been used to estimate muskrat population densities for agricultural field habitat.

Table 6. Development of Muskrat Fecal Coliform Loads (cfu/acre-day)

Habitat	Pop. Density (per mile of ditch) *(per square mile)*	Pop. Density (per acre)	Waste Load (cfu/animal-day)	FC Load (cfu/acre-day)
Primary (Ag Fields)	16	0.65152	1.90E+08	**1.24E+08**
Secondary (Shoreline)	*1280*	2	1.90E+08	**3.80E+08**

Nutria

Nutria, a member of the rodent species, are not native to Virginia. They migrated north from the Gulf Coast area of the United States. At one time important furbearers, nutria were often released once the trade of their fur was no longer lucrative (American University, 2008). The species can be overly destructive of habitat, adversely affecting both muskrat and waterfowl populations (NTA, 2005). Nutria habitat has been identified as the optimal water habitat preferred by muskrats – see the preceding section on muskrats. Figure 5 provides a graphical depiction of nutria habitat.

Nutria are thought of as colonial because the same den is shared by one dominant male and two or three females along with their offspring. Female nutria reproduce throughout the year. There is a short gestation period and the average litter size is 5. Four to five colonies of nutria to one mile of levees or dikes indicates a high population; a family or colony territory is about 1,000 feet in length (NTA, 2005).

Table 7. Development of Nutria Fecal Coliform Loads (cfu/1,000 ft shoreline-day)

Nutria Age	Pop. Density (per 1,000 ft shoreline)	Waste Load (cfu/animal-day)	FC Load (cfu/1,000 ft shoreline-day)
Adult	3.5	6.555E+07	**4.60E+08**
Youth	12.5	1.843E+07	

Raccoons

The primary raccoon habitat range is 600 feet from the shoreline as shown in Figure 6 (MapTech, 2005). Raccoon numbers were estimated at 50 per square mile in primary habitat areas and 10 per square mile in secondary habitat areas (Fies, 2005). These estimates yielded numbers close to other studies (Herman, 2005) and were used in calculating raccoon population for the entire basin.

Table 8. Development of Raccoon Fecal Coliform Loads (cfu/acre-day)

Habitat	Pop. Density (per square mile)	Pop. Density (per acre)	Waste Load (cfu/animal-day)	FC Load (cfu/acre-day)
Primary	50	0.07813	9.45E+08	**7.38E+07**
Secondary	10	0.01563	9.45E+08	**1.48E+07**

LIVESTOCK CONTRIBUTIONS

The Nanney Creek Basin, located in the City of Virginia Beach, is primarily agricultural in nature. While the majority of the agricultural land is used for crop production, a significant portion is used to raise or board livestock. Dog kennels have been included in this category, although not technically livestock. Through site visits, public comment, and personal interviews (Salmons & Vaughan, 2008), the locations and types of livestock raised or boarded in the Nanney Creek Basin were identified (see Figure 7). Chickens and turkeys were also identified within the study area, though not in significant numbers.

There are several ways in which livestock fecal coliform contributions can enter surface waters. Based on field observations and personal interviews (Salmons & Vaughan, 2008), it was assumed that all livestock species – with the exception of hogs – graze throughout the day and therefore deposit waste onto the land on which they are kept.

Land Deposition

All livestock species are assumed to deposit manure to the land on which they are kept for a portion of the day. The following species were assumed to be in pasture for 24 hours each day: cattle, goats, horses, sheep, and dogs. Hogs typically graze from 7 to 12 hours each day (Lyons & Machen).

Animal populations for several species at specific locations in the study area were provided through public comment or personal interview (Salmons & Vaughan, 2008). Population densities (animals/acre) for dogs, cattle, sheep and goats were developed for the specific location and applied throughout the watershed. The population for hogs was based on an average swine concentration in the watershed as published by the Department of Conservation and Recreation in 2006 (DCRb). Due to the season and time of day during which field investigations were conducted, local stakeholders and the U.S. Fish & Wildlife Service indicated that the horse population within the study area was likely to be greater than observed. It was therefore assumed that 2 to 3 horses are boarded at each horse location displayed by Figure 7.

Table 9. Development of Livestock Fecal Coliform Loads (cfu/acre-day)

Species	Pop. Density (per acre)	Waste Load Produced (cfu/animal-day)	Time in Pasture (%)	FC Load (cfu/acre-day)
Cattle	0.52424	9.58E+08	100	**5.02E+08**
Dogs	15.625	2.16E+08	-- [A]	**0.00E+00**
Goats	16.917	1.11E+08	100	**1.88E+09**
Horses	0.3976	2.17E+09	100	**8.65E+08**
Hogs	8.3544	2.05E+09	50	**8.56E+09**
Sheep	8.1363	4.68E+07	100	**3.81E+08**

A. Boarded dogs do spend time outside. For the purpose of this study, it was assumed that the kennel owners scoop 100% of the waste and dispose of it in a recommended fashion.

Manure Application

While local residents have indicated that manure application is a common occurrence in the study area, information was not available to accurately establish the type, amount, location, form, timing, and methods of manure application. Virginia Department of Conservation and Recreation has established Nutrient Management Standards and Criteria that govern the storage and application of manure in Virginia. While the standards (DCRa) are useful in developing site-specific nutrient management plans and determining appropriate manure application schedules for individual farms, they do not provide limits applicable to all study area croplands. Instead, the criteria require that facilities apply only the amount of nutrients (in this case manure) agronomically required by the crop (DCRa).

Residents reported applying cattle manure to fields in the study area. Using BEJ, it was assumed that the manure was spread upon the same property on which the animals are kept. Therefore, cattle manure application was treated as land deposition.

Based on the grazing assumption made in the preceding section, hogs thus spend 50% of their time in confinement. Though the particular method of manure storage is unknown, pit – or lagoon – storage is common. The typical storage period in a manure lagoon ranges from 5 to 12 months (Tetra Tech, 2004). It was therefore assumed that all manure collected while in confinement is available for application to croplands (3811 acres) in the study area. A reduction in fecal coliform levels of 2-3 orders of magnitude is typical with storage for 2 to 6 months (Tetra Tech, 2004). Therefore, the fecal load of the applied hog manure was reduced to account for storage prior to application.

The best time to apply manure varies by differences in climate, crops grown, soils, and specific sites characteristics. Spring is often the optimal time to land apply manure to conserve the greatest amount of nutrients (Tetra Tech, 2004). Fall application usually results in greater nutrient losses, especially when the manure is not incorporated into the soil. However, fall applications allow for more complete decomposition of manure and release nutrients for the next growing season (Tetra Tech, 2004). Therefore, all collected hog manure throughout the year will be applied to croplands from March to May (spring) and September to November (fall) for a total of 183 days. To be conservative, it was assumed that the manure was not incorporated after application as is available for wash-off during a rainfall event.

Table 10. Development of Manure Fecal Coliform Loads (cfu/acre-day)

Hog Population in WS 24	Stored FC Density (cfu/g)	Stored Waste Load (cfu/animal-day)	Stored Waste Load (cfu/WS-year)	FC Load (cfu/crop acre-day)
609	400	1.03E+06	2.28E+11	**3.27E+05**

HUMAN AND PET CONTRIBUTIONS

Pets

Dogs and cats were the only pets considered in this analysis. Due to their small application rate (19.4 g/an-day) and low fecal coliform density (9 cfu/g) as compared with dogs, cats were excluded from further analysis. Dog fecal coliform loading was applied to all residential land uses. Residential land uses were originally developed using hard-copy City zoning maps and were refined based on site visits and public comment (see Technical Memorandum – Drainage Pattern Determination & Land Use Development). Using these classifications, the average number of units per acre was developed for each land use (Virginia Beach Code of Ordinances, 2007). The dog population per acre was determined by multiplying the number of units by 0.361, the number of households owning dogs, and by 1.6, the average number of dogs in each household owning dogs (AVMA, 2002). It was assumed using BEJ that no dog owners "scoop the poop" within the rural study area. Therefore, the daily coliform loading for each residential land use is calculated as shown in Table 10.

Table 10. Development of Pet Fecal Coliform Loads (cfu/acre-day)

Land Use Category	Units/Acre	Pop. Density (per acre)	Waste Load (cfu/animal-day)	FC Load (cfu/acre-day)
BAG	1.00	0.57760	2.16E+08	**1.25E+08**
SFM	4.02	2.32195	2.16E+08	**5.02E+08**
SFL	1.45	0.83752	2.16E+08	**1.81E+08**
SFH	7.74	4.47062	2.16E+08	**9.66E+08**

Failing / Malfunctioning Septic Systems

Public sanitary facilities have not been extended to southern Virginia Beach area and therefore the entirety of the study area relies on private sewerage systems. As a part of this effort, a database of septic systems in Virginia Beach Watershed 24 was developed. Applications by Virginia Beach residents for new private septic systems or requests for modifications to existing systems were provided in database format by the Virginia Department of Health (VDH). Using provided attribute data and best engineering judgment (BEJ), records meeting the following criteria were retained for inclusion in the Watershed 24 septic system database: (1) address within the study area and (2) application NOT denied (many database entries had no recorded approval date, but were not denied). Retained records were then compared to land use information gathered as a part of the modeling effort (see Technical Memorandum – Drainage Pattern Determination & Land Use Development). The Watershed 24 septic system database was supplemented with additional septic system records for parcels identified as commercial establishments or having one or more homesteads and not represented by retained VDH data. Figure 8 provides a graphical depiction of septic system locations in the study area. An average of 2.7 persons per system (US Census Bureau, 2000) and an average daily flow of 75 gallons per day per person (VDH, 2000) were used to develop the average daily flow per septic system. The fecal coliform concentration in septic tank effluent was multiplied by the estimated septic leakage rate to determine the total load from each failing system. Representation of failing septic systems in the HSPF model has been documented in Technical Memorandum – Septic System Loading and Impact.

Biosolids Application

Biosolids, processed by Hampton Roads Sanitation District (HRSD), have been applied to permitted agricultural fields within the study area. Data were provided by HRSD detailing the fecal coliform content of the biosolids as well as application dates and rates for each land tract for the period 2000 through 2006. See Figure 9 for sites in the study area that are either permitted for or have had biosolids applied within the period of interest. Representation of biosolids application in the HSPF model will be documented in a subsequent technical memorandum.

HSPF PARAMETERS

HSPF has separate modules for the pervious and impervious land segments as well as in-stream fate and transport processes. These modules are identified as PERLND, IMPLND, and RCHRES, respectively. The generalized water quality constituent routines for each of the aforementioned modules – PQUAL, IQUAL, and GQUAL – were used to simulate the land-based and in-stream processes related to the constituent, fecal coliform bacteria.

ASSOCIATED WITH LAND-BASED PROCESSES (PQUAL & IQUAL)

Consistent with HSPF training literature and other studies, removal of accumulated fecal coliform bacteria has been associated with overland flow (BASINSa). The constituent has not been associated with interflow or groundwater.

MON-ACCUM & MON-SQOLIM

These parameters were calculated based on the loads developed in previous sections. MON-ACCUM is the daily nonpoint fecal coliform load per acre applied to each land use. Fecal coliform loads for all sources discussed above, with the exception of septic tanks, nutria, and some muskrats, were applied in this fashion. MON-SQOLIM is the maximum accumulation of the pollutant per acre land and implicitly represents bacterial die-off. These values were calculated as nine times (9x) the daily accumulation rates. This is consistent with bacterial TMDL reports in Virginia (Vann et al., 2005).

WSQOP

WSQOP is the rate of surface runoff that will remove ninety percent (90%) of the accumulated pollutant per hour. This parameter is initially estimated and later calibrated. Attempts were made to procure values of WSQOP that were employed in the HSPF simulation used in development of the Virginia Beach Coastal Area TMDL. However, no values were provided. Therefore, values of 0.5 in/hr for pervious land segments and 0.4 in/hr for impervious land segments (with the exception of water, wetlands, and BMPs) were used. The value of WSQOP for water, wetlands, and BMPs was set as 0.2 in/hr as documented in a guidance document included as a part of the BASINS 3.1 software package (BASINSb).

ASSOCIATED WITH IN-STREAM PROCESSES (GQUAL)

Once the fecal coliform entered the stream, the general decay module of HSPF was incorporated, consistent with the process employed in development of the Bacterial TMDL for the Virginia Beach Coastal Area (MapTech, 2005). The general decay module uses a first order decay function to simulate die-off.

MON-WATEMP

Monthly water temperature values are consistent with those used to develop water quality constituent simulations (URS, 2007) as a part of the Lynnhaven River Watershed modeling effort.

FSTDEC

An in-stream first order decay rate (at 20 degrees Celsius) of 1.15 day^{-1} (Vann et al., 2005) was used.

THFST

THFST, a temperature correction term used in conjunction with FSTDEC, was set at 1.05. This value is consistent with Virginia TMDL reports (Vann et al., 2005).

CONCLUSIONS

Watershed model output is representative of fecal coliform sources applied to land surfaces and stream segments. Sources of fecal coliform applied to the Nanney Creek Basin were identified through field visits, public comment, personal interviews, and literature research.

The population estimates and loading rates used in the HSPF simulation have been reviewed by several sources not directly involved with this effort, including several VDGIF personnel and a URS employee proficient in pollutant modeling using HSPF. Habitat areas were refined based on public comment and personal interviews with area farmers, wildlife experts, and Virginia Department of Environmental Quality (VADEQ) personnel.

REFERENCES

Allen, A.W., and R.D. Hoffman. 1984. *Habitat suitability index models: Muskrat*. U.S. Fish Wildl. Serv. FWS/OBS-82/10.46. 27 pp.

American University. *Nutrias in the U.S. and Trade*.http://www.american.edu/TED/NUTRIA.HTM as of 2 Feb. 2008.

American Veterinary Medical Association (AVMA). 2002. *U.S. Pet Ownership & Demographic Sourcebook.*

BASINS 3.1 (BASINSa). *BASINS/HSPF Training Appendix F – Manually Adding Temperature and Fecal Coliform.*

BASINS 3.1 (BASINSb). *pollutants.txt.* Located in the BASINS 3.1 software download at BASINS\models\HSPF\bin.

"Behaviors and nutritional importance of coprophagy in captive adult and young nutrias (Myocastor coypus)." May 1998. *Journal of comparative Physiology B: Biochemical, Systematic, and Environmental Physiology.* 168.4: 281-88.

Chesapeake Bay Program (CBP). December 2007. *Waterfowl General Information.* http://www.chesapeakebay.net/waterfowl.htm as of 12 Feb. 2008.

Fairfax County. 2008. *Deer Management FAQs – Fairfax County, Virginia.* http://www.fairfaxcounty.gov/comm/deer/deerfaqs.htm as of 14 Jan. 2008.

Fies, Mike, Small Game Research Biologist; Virginia Dept. of Game and Inland Fisheries. *Raccoon and Muskrat Population Estimates.* E-mail to Julie Herman, Ph.D. 23 Sept. 2005.

French, L., and J. Parkhurst. November 2001. *Managing Wildlife Damage: Canada Goose.* Publication #420-203; http://www.ext.vt.edu/pubs/wildlife/420-203/420-203.html.

Gallegos, John. Personal interview. 16 Jan. 2008.

Harper, Scott April 2006. *Signature Bay Duck on the Decline; Reasons Unknown.* The Virginian-Pilot. http://www.wtopnews.com/index.php?nid=25&sid=1009915# as of 1 Feb. 2008.

Herman, Julie, Ph.D., Center for Coastal Resources Management; Virginia Institute of Marine Science. *Re: raccoon numbers.* E-mail to Shane Brennan. 23 Sept. 2005.

Horsley and Witten, Inc. 1996. *Identification and evaluation of nutrient and bacterial loadings to Maquoit Bay, New Brunswick and Freeport, Maine.* Final Report.

Lyons, R.K. & Machen, R.V. *Interpreting Grazing Behavoir.* Prepared for the Texas Agricultural Extension Service, Texas A&M University System.

MapTech, Inc. April 2005. *Development of Bacterial TMDLs for the Virginia Beach Coastal Area (London Bridge Creek & Canal # 2, Milldam Creek, Nawney Creek, West Neck Creek (Middle), and West Neck Creek (Upper)*. Prepared for the Virginia Department of Environmental Quality.

MapTech, Inc. February 2001. *Fecal Coliform TMDL Development for Maggodee Creek, Virginia*. Prepared for the Virginia Department of Environmental Quality and Virginia Department of Conservation and Recreation.

National Trappers Association (NTA). 2005. *Nutria.* http://www.nationaltrappers.com/nutria.html as of 28 Jan. 2008.

Salmons, David & Vaughan, Bobbie. Personal interview. 16 Jan. 2008.

Tetra Tech, Inc. December 2004. *EPA Regional Priority AFO Science Question Synthesis Document – Manure Management.* Prepared for the U.S. Environmental Protection Agency, Office of Science Policy, & Office of Research and Development. http://www.manure.umn.edu/regulatory/5Manure%20Management.pdf

United States Dept. of Agriculture (USDA). *Fire Effects Information System.* http://www.fs.fed.us/database/feis/ as of 26 Oct. 2005.

URS Corporation (URS). February 2007. *Technical Memorandum – Historic Water Quality Monitoring Data Evaluation.* Prepared for the City of Virginia Beach Department of Public Works.

US Census Bureau. 2000. *Quick Facts, Virginia Beach City, Virginia.* http://quickfacts.census.gov/qfd/states/51/51810.html

U.S. Environmental Protection Agency (USEPA). January 2001. *Protocol for Developing Pathogen TMDLs.* EPA 841-R-00-002. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

U.S. Fish & Wildlife Service (USFWSa). *Back Bay National Wildlife Refuge.* http://library.fws.gov/Refuges/BACKBAY.pdf as of 28 Jan. 2008.

U.S. Fish & Wildlife Service (USFWSb). 1996. *Birds of Back Bay National Wildlife Refuge, Virginia Beach, Virginia.* U.S. Fish & Wildlife Service. Unpaginated. http://www.npwrc.usgs.gov/resource/birds/chekbird/r5/backbay.htm as of 10 Feb. 2008.

Vann, D.T., et al. December 2005. *The District of Columbia Source Water Assessment.* Prepared for Environmental Health Administration, Department of Health, Government of the District of Columbia. 6-19, 20 pp. http://www.potomacriver.org/water_quality/dcswap/

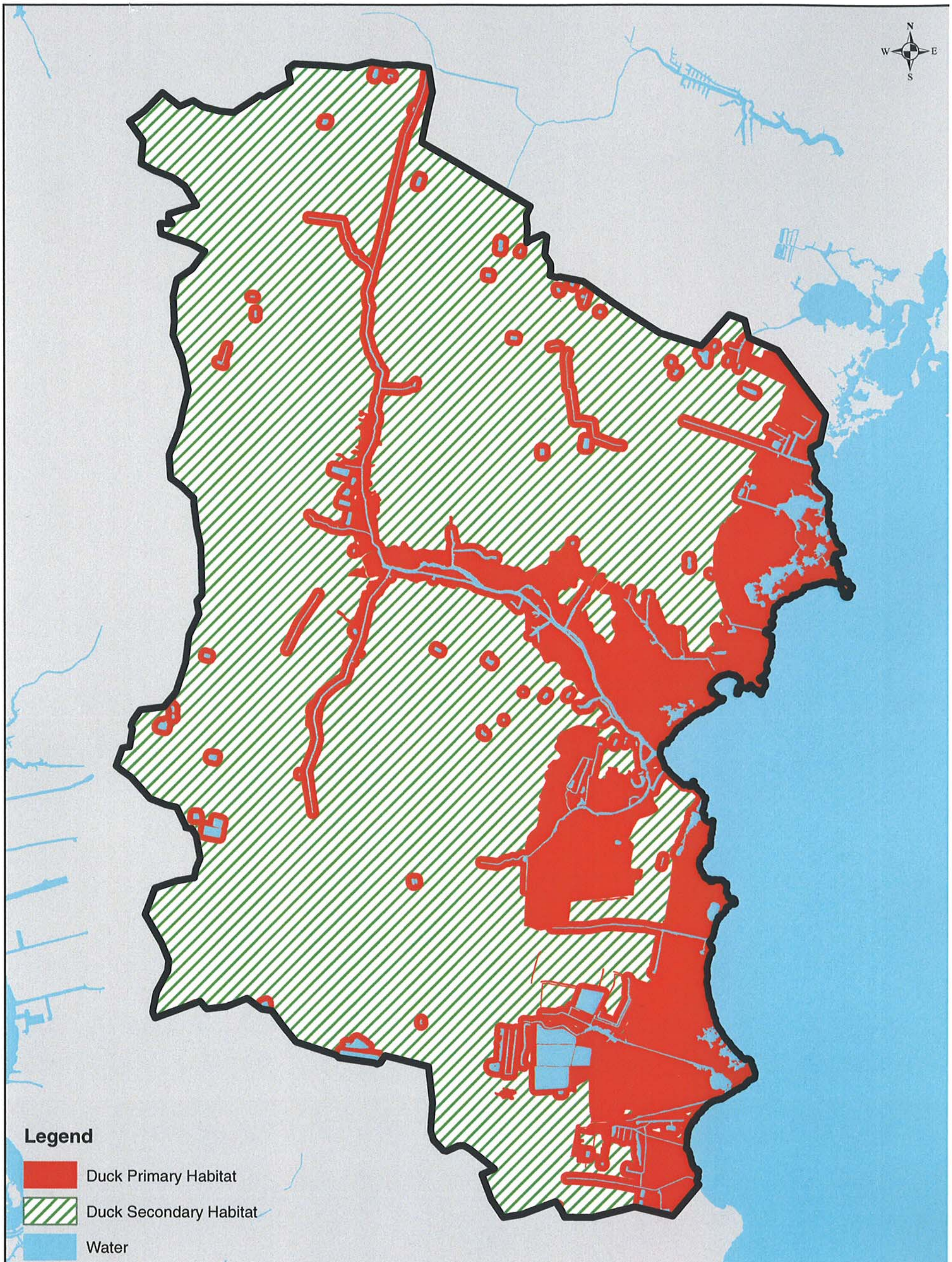
Virginia Beach Code of Ordinances. 2007. *Zoning Ordinance.*http://www.municode.com/Resources

Virginia Department of Conservation and Recreation (DCRa). October 2005. *Virginia Nutrient Management Standards and Criteria*. http://www.dcr.virginia.gov/documents/StandardsandCriteria.pdf

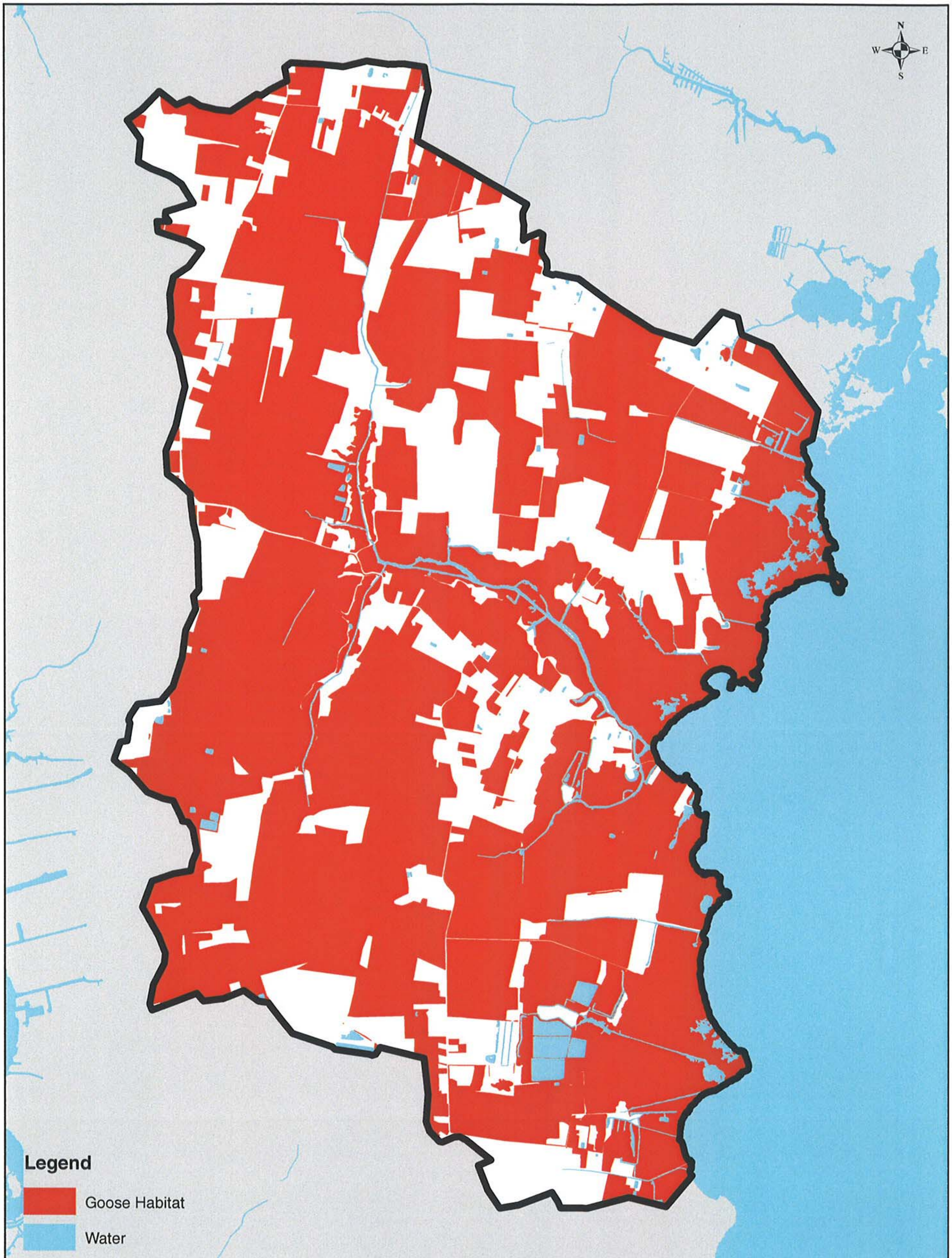
Virginia Dept. of Conservation and Recreation (DCRb). January 2006. *Swine Concentrations.*

Virginia Dept. of Game and Inland Fisheries (VDGIF). *Virginia Fish and Wildlife Information System.* http://vafwis.org/WIS/ASP/default.asp as of 4 Nov. 2005.

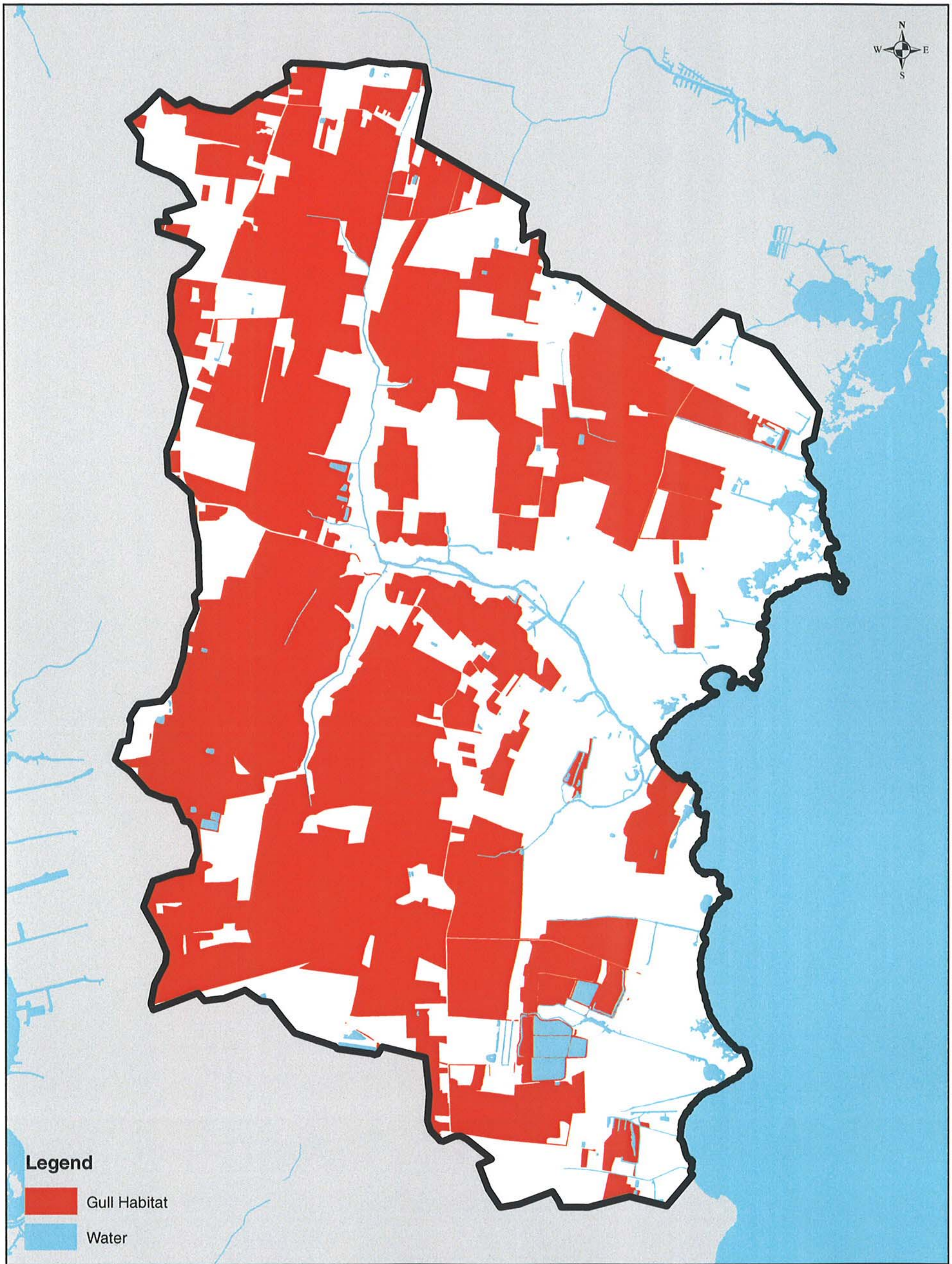
Virginia Department of Health (VDH). July 2000. *Sewage Handling and Disposal Regulations.* 12VAC5-610-670. Sewage Flows.



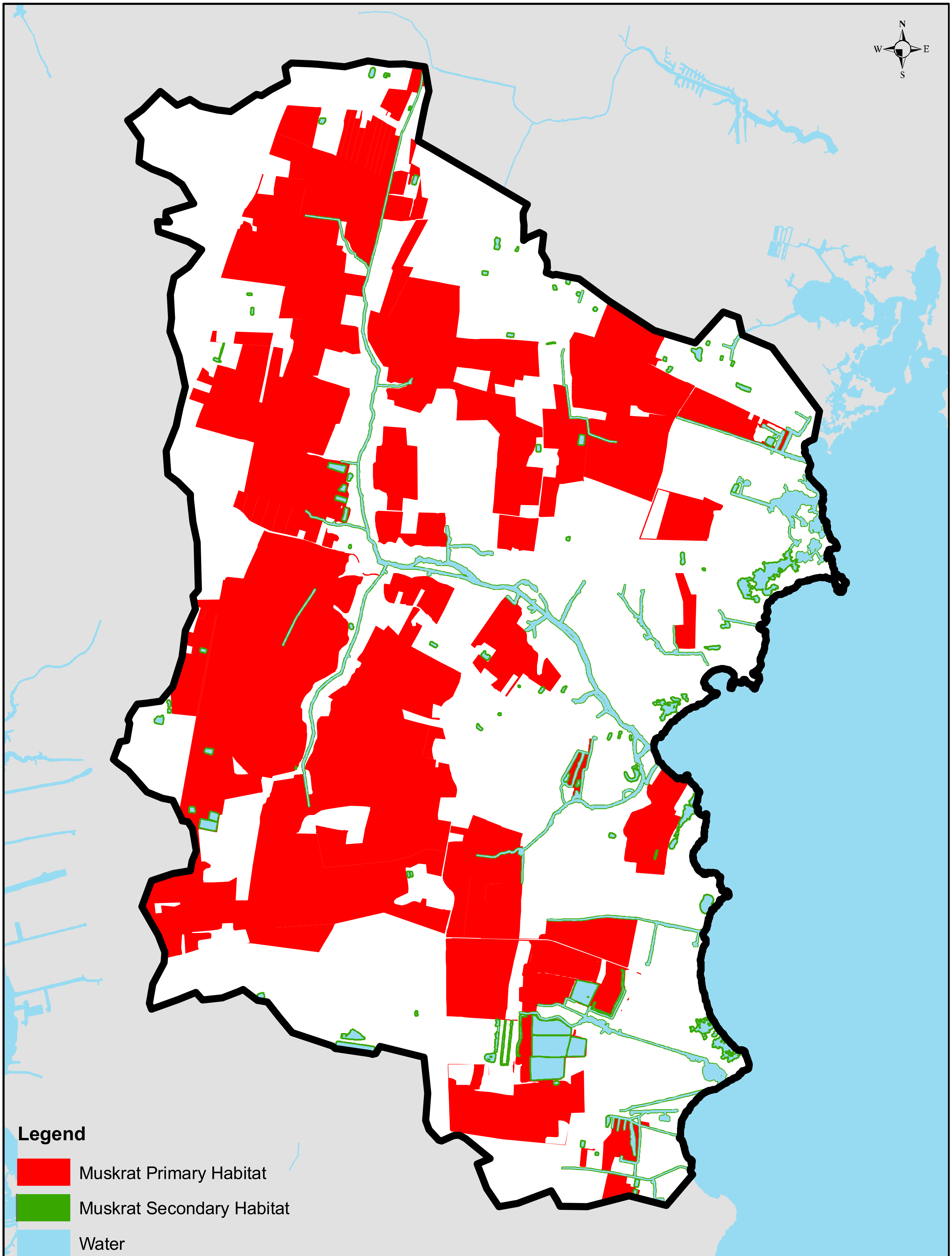
Fecal Coliform Loading Watershed 24 (including Nanney Creek Basin)
Figure 1 Duck Habitat



Fecal Coliform Loading Watershed 24 (including Nanney Creek Basin)
Figure 2 Goose Habitat

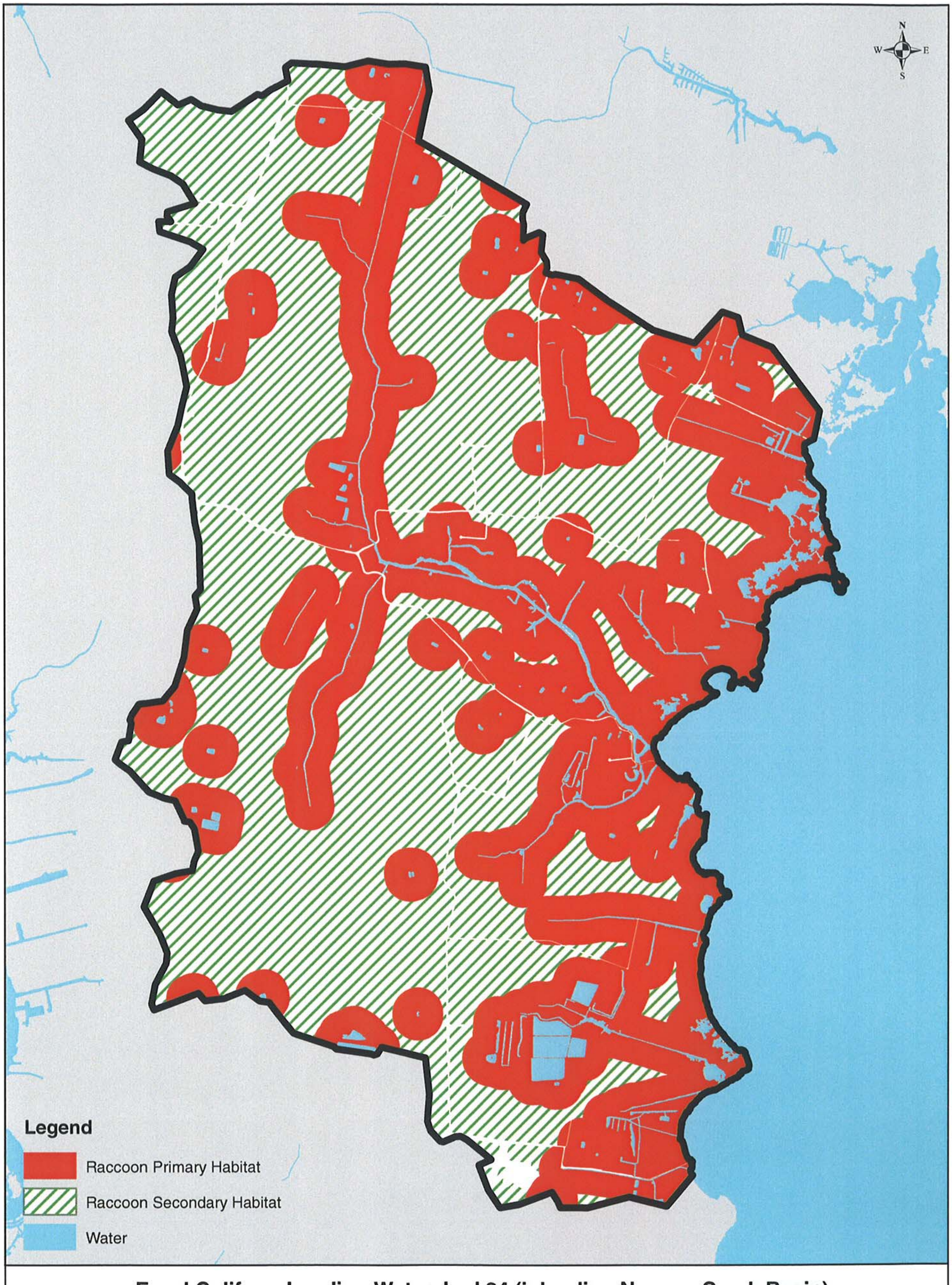


Fecal Coliform Loading Watershed 24 (including Nanney Creek Basin)
Figure 3 Gull Habitat

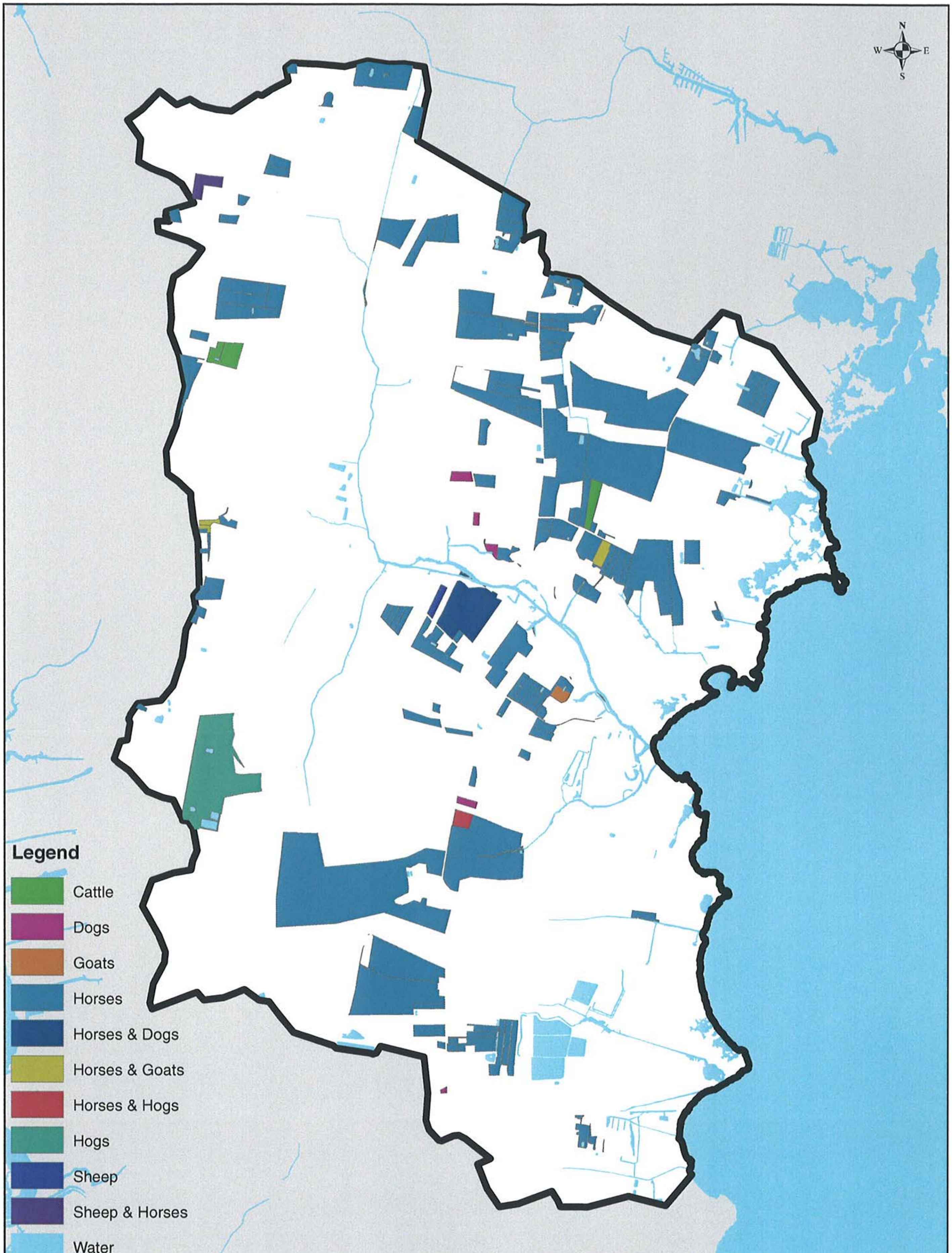


Fecal Coliform Loading Watershed 24 (including Nanney Creek Basin)
Figure 4 Muskrat Habitat

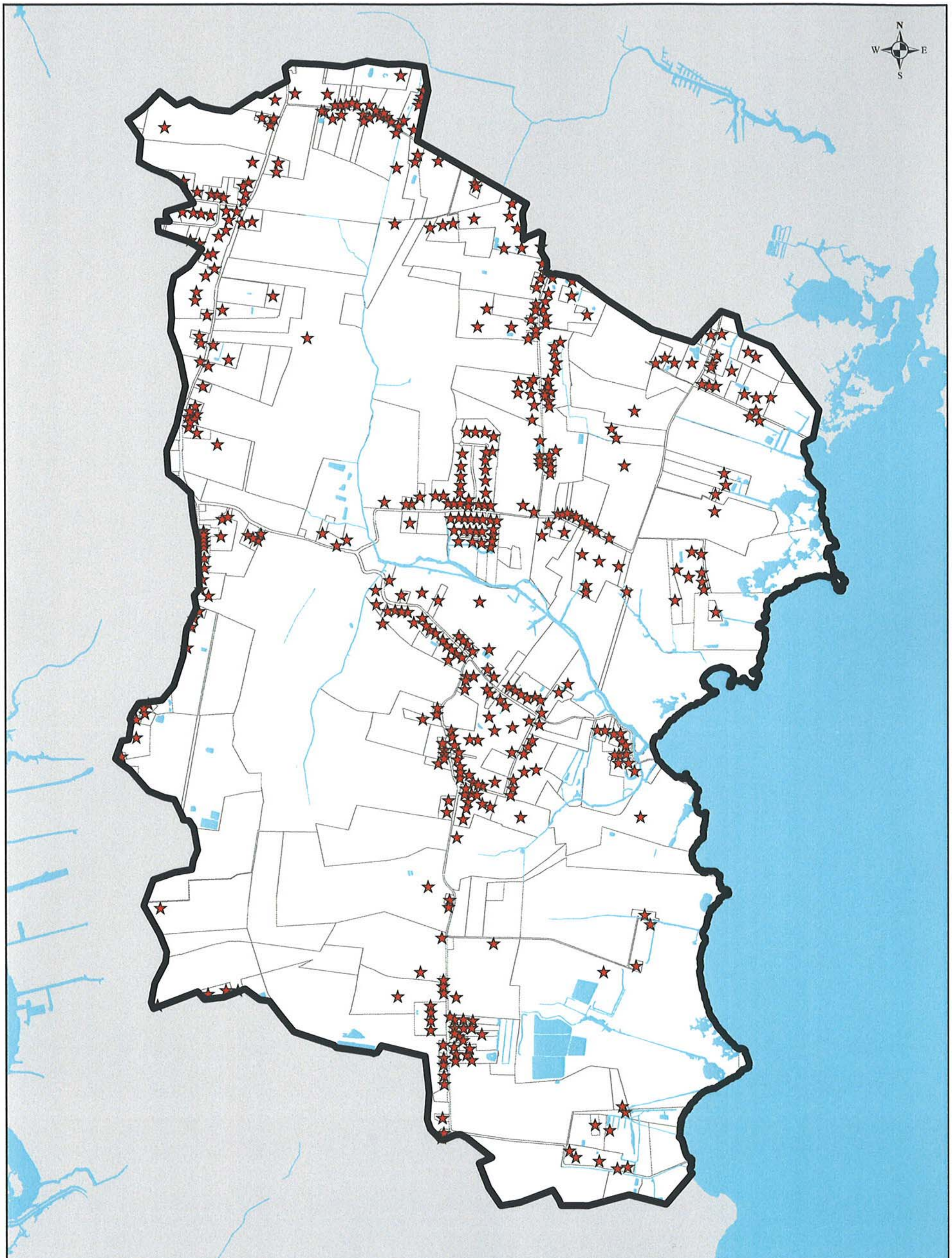
Fecal Coliform Loading Watershed 24 (including Nanney Creek Basin)
Figure 5 Nutria Habitat



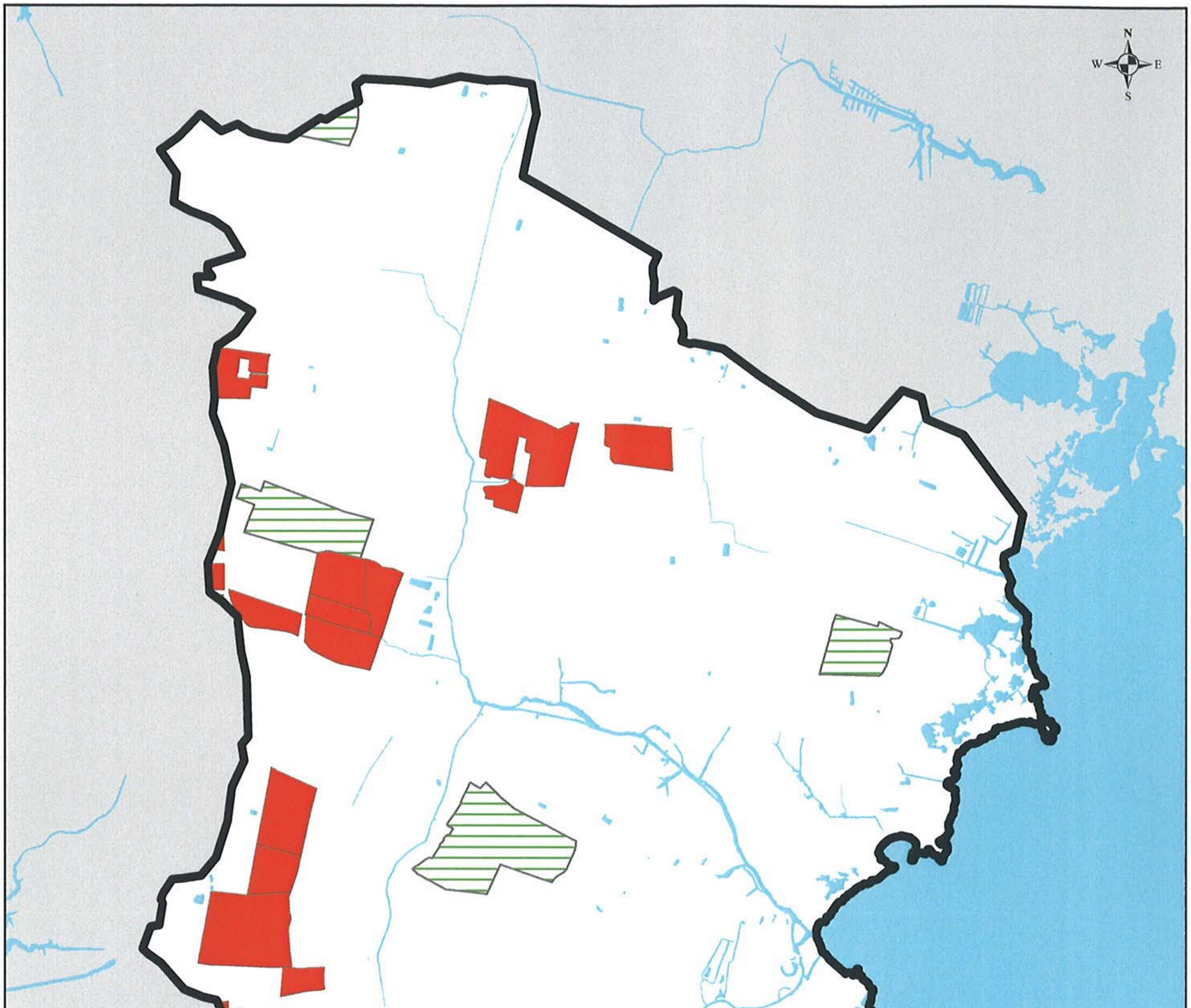
Fecal Coliform Loading Watershed 24 (inlcuding Nanney Creek Basin)
Figure 6 Raccoon Habitat



Fecal Coliform Loading Watershed 24 (including Nanney Creek Basin)
Figure 7 Livestock



Fecal Coliform Loading Watershed 24 (including Nanney Creek Basin)
Figure 8 Septic Systems



Fecal Coliform Loading Watershed 24 (including Nanney Creek Basin)
Figure 9 Biosolids Application

Date:	August 25, 2008
To:	Southern Rivers Watershed TMDL Implementation Plan TAC
From:	Bill Johnston, Virginia Beach Department of Public Works
Subject:	**Nanney Creek Watershed HSPF – Fecal Coliform Simulation** **Updated Bacterial Source Populations Compared to TMDL Populations**

Sources of fecal coliform bacteria in the Nanney Creek Watershed were identified through extensive field work, public comment, interviews, meetings w/ VDEQ, and watershed modeling using Hydrologic Simulation Program – Fortran (HSPF). The resulting habitats and population densities for bacterial sources were identified under separate cover in the form of technical memoranda. The purpose of this memorandum is to present the resulting populations in the Nanney Creek Watershed and compare them with those developed as part of the TMDL effort. The data is presented in the following table.

	TMDL	CURRENT EFFORT
WILDLIFE		
BEAVERS	34	0[1]
DEER	60	211[2]
DUCKS	38	43
GEESE	14	256
GULLS	113	209
MUSKRATS	321	1601
NUTRIA	0	533
ADULT	*0*	*117*
YOUTH	*0*	*417*
RACCOONS	272	227
LIVESTOCK		
CATTLE	0	8
GOATS	0	154
HORSES	15	275
HOGS	3727	609
SHEEP	0	77
HUMAN AND PET		
DOGS	141	431
CATS	158	0[3]
SEPTIC TANKS	260	352
FAILING	*40*	*35[4]*
UNCONTROLLED DISCHARGES	4	UNK[5]

1. Based on public input, beaver are not a considerable source of bacteria in the Nanney Creek Watershed.
2. Deer population density was developed through model calibration as described in Technical Memorandum – Existing Conditions and Source Reduction Scenarios. The resulting deer population exceeds that developed for the TMDL effort. While VDGIF supports a maximum deer population density of 18.8 per square mile in the southern, rural portion of Virginia Beach, model calibration supports a significantly higher density. The reported deer population of 211 deer corresponds to a deer population density of 25 deer per square mile, consistent with citizen input. The City intends to better enumerate deer population in Nanney Creek as a part of the implementation phase of the TMDL.
3. Cat populations were not enumerated due to their extremely small fecal load.
4. Failing septic systems and other human bacterial contributions were estimated using the HSPF model and VDEQ monitoring data (bacterial enumerations and BST) as described in Technical Memorandum – Septic System Loading and Impact.
5. While no uncontrolled discharges were physically identified within the study area, the impact of uncontrolled discharges to Nanney Creek has been implicitly included in the modeling effort while developing septic (and other human) contributions.

TECHNICAL MEMORANDUM
EXISTING CONDITIONS, REVISION 1

Prepared for: City of Virginia Beach, Virginia
Department of Public Works

Prepared by: URS Corporation
Virginia Beach, Virginia

Date: Resubmitted August 20, 2008
Previously Submitted June 20, 2008

Contract: PWCN-6-0026
Work Order 13A – Water Quality Model for Nanney Creek Basin
URS Project No. 11657119

PURPOSE

One objective of the water quality modeling effort for the Nanney Creek Basin was to simulate fecal coliform concentrations in surface runoff using the Hydrologic Simulation Program – Fortran (HSPF). Once calibrated, the model shall be used to determine bacterial source load reductions required to meet applicable water quality standards. This memorandum describes the calibration process to arrive at the existing conditions simulation.

EXISTING CONDITIONS SIMULATION

Previous work conducted as a part of the overall modeling effort included land use and drainage determinations, as well as fecal coliform loading estimates for the study area. See Technical Memoranda – Drainage Pattern Determination & Land Use Development and Fecal Coliform Loading, Revision 4. Fecal coliform loads from failing and malfunctioning septic tanks in the study area were developed and calibrated under separate cover. See Technical Memorandum – Septic System Loading and Impact. Using this data and representative Virginia Department of Environmental Quality (VDEQ) monitoring data, HSPF model inputs were adjusted until model output showed reasonable agreement with observed data.

CALIBRATION EFFORTS

No independent hydrologic calibration was conducted as a part of this effort. However, the majority of hydrologic parameters used in the Nanney Creek HSPF model mirror those developed as part of the Lynnhaven River Watershed model, which was hydrologically calibrated. Since Nanney Creek is predominantly agricultural in nature, parameters associated with agricultural land uses were thoroughly researched and were selected accordingly. Finally, biosolids have been applied to agricultural croplands within the watershed. The use of biosolids improves soil characteristics such as soil moisture and infiltration capacities. A separate HSPF model of the Hampton Roads

Sanitation District (HRSD) Progress Farm was developed and calibrated to ensure that biosolids application was handled appropriately in the Nanney Creek model.

The fecal coliform source load estimates developed in the aforementioned technical memorandum provided initial loading conditions for water quality calibration scenarios. As was expressed in that memorandum, the initial model simulation assumed a density of 400 deer per square mile over the entirety of the study area. Resulting fecal coliform concentrations from the simulation were then compared to available water quality observations at two VDEQ monitoring stations within the study area; Station 5BNWN001.84 (Upper Nanney Creek) and Station 5BNWN000.00 (Lower Nanney Creek). See Attachment A – Calibration Results for fecal coliform concentrations resulting from the initial simulation.

The initial simulated fecal coliform concentrations showed partial agreement with higher observed values; simulated peak concentrations exceeded 10,000 cfu/100mL. However, simulated concentrations were consistently higher than observed values less than 300 cfu/100mL. Therefore, it was determined that the calibration effort must address both point sources, such as muskrat and nutria contributions, which establish the baseline bacterial concentrations in the creek and nonpoint sources, such as deer, which affect in-stream concentrations following storm events.

Adjustments to nutria, muskrat, and deer populations were made until reasonable agreement between model output and water quality observations was obtained. Attachment A – Calibration Results presents in-stream fecal coliform concentrations and corresponding VDEQ monitoring data for the final calibration scenario on log-scale. Log-scale tends to exaggerate the difference between values on the low end of the scale.

Overall agreement is good between observed and simulated fecal coliform concentrations for the final calibration scenario at Station 5BNWN001.84 as shown in Figures 1 through 4 of Attachment A – Calibration Results. The location of Station 5BNWN001.84 (Upper Nanney Creek) makes it the best calibration metric for this effort. Since this station is predominantly influenced by upstream conditions, the HSPF model was capable of generating realistic in-stream concentrations. Bacteria from identified sources within the watershed were input to the model based on land use or proximity to the creek. Land use categories are well distributed throughout the Nanney Creek Basin. Therefore, bacterial loads affecting in-stream fecal coliform concentrations at Station 5BNWN001.84 have been applied using the same methodology throughout the remainder of the study area. Figures 5 through 8 provide simulated versus observed fecal coliform concentrations at Station 5BNWN000.00 (Lower Nanney Creek). The station is located at the mouth of Nanney Creek at its confluence with Back Bay. Simulated in-stream concentrations for the final calibration scenario at Station 5BNWN000.00 do not agree with many of the low observed values. Since bacterial loads affecting this station were applied using the same methodology as those resulting in reasonable agreement at Station 5BNWN001.84, discrepancies at Station 5BNWN000.00 are attributed to variable, unknown bacterial conditions in Back Bay that influence the model boundary condition.

The final calibration scenario corresponds to a deer population density of 25 deer per square mile, consistent with citizen input. While Virginia Department of Game and Inland Fisheries (VDGIF) supports a maximum deer population density of 18.8 per square mile in the southern, rural portion of Virginia Beach, model calibration supports a significantly higher density.

The nutria population was reduced to twenty-five percent (25%) of the previously estimated population. This population adjustment is justified based on comments from area residents who noted that the nutria population has decreased dramatically due to severe winter weather within the past decade.

The muskrat habitat was altered to retain only the agricultural ditch (nonpoint source) habitat; the shoreline (point source) habitat was eliminated. Adjustment of the muskrat habitat is reasonable based on area residents' comments concerning the on-going invasion of muskrat habitat by nutria.

The resulting source populations are presented in the following table.

Table 1. Bacterial Source Populations for Nanney Creek –TMDL vs. Current Effort

Source	TMDL	Nanney Creek WQ Model
WILDLIFE		
BEAVERS	34	0[1]
DEER	60	211[2]
DUCKS	38	43
GEESE	14	256
GULLS	113	209
MUSKRATS	321	1601
NUTRIA	0	533
ADULT	*0*	*117*
YOUTH	*0*	*417*
RACCOONS	272	227
LIVESTOCK		
CATTLE	0	8
GOATS	0	154
HORSES	15	275
HOGS	3727	609
SHEEP	0	77
HUMAN AND PET		
DOGS	141	431
CATS	158	0[3]
SEPTIC TANKS	260	352
FAILING	*40*	*35[4]*
UNCONTROLLED DISCHARGES	4	UNK[5]

1. Based on public input, beaver are not a considerable source of bacteria in the Nanney Creek Watershed.
2. Deer population density was developed through model calibration as described in Technical Memorandum – Existing Conditions and Source Reduction Scenarios. The resulting deer population exceeds that developed for the TMDL effort. While VDGIF supports a maximum deer population density of 18.8 per square mile in the southern, rural portion of Virginia Beach, model calibration supports a significantly higher density. The reported deer population of 211 deer corresponds to a deer population density of 25 deer per square mile, consistent with citizen input. The City intends to better enumerate deer population in Nanney Creek as a part of the implementation phase of the TMDL.
3. Cat populations were not enumerated due to their extremely small fecal load.
4. Failing septic systems and other human bacterial contributions were estimated using the HSPF model and VDEQ monitoring data (bacterial enumerations and BST) as described in Technical Memorandum – Septic System Loading and Impact.
5. While no uncontrolled discharges were physically identified within the study area, the impact of uncontrolled discharges to Nanney Creek has been implicitly included in the modeling effort while developing septic (and other human) contributions.

RESULTS

The following table provides annual fecal coliform loads from the Nanney Creek Basin for existing conditions. TMDL values are also provided. Attachment B – Source Representation presents the land use categories contributing to each of the land based sources identified below as well as the nonpoint sources contributing to each land use category for existing conditions.

Table 2. Land-based and Direct Fecal Coliform Loads with TMDL Comparison

Source	Total Annual Load For Existing Conditions (cfu/yr)	
LAND BASED	Nanney Creek WQ Model	*TMDL*
COMMERCIAL	1.39E+13	*1.44E+12*
CROPLAND[1]	5.43E+14	*3.76E+14*
PASTURE[2]	9.04E+13	*5.96E+13*
RESIDENTIAL	9.00E+13	*3.02E+13*
STREETS	3.41E+11	*NA*
WATER	0.00E+00	*0.00E+00*
WETLANDS	1.77E+13	*6.51E+13*
WOODLANDS	1.78E+13	*9.74E+12*
DIRECT		
HUMAN	1.02E+12	*1.10E+13*
LIVESTOCK	0.00E+00	*0.00E+00*
WILDLIFE[3]	5.59E+12	*1.07E+13*

1. The Total Annual Load for Existing Conditions for CROPLAND includes the annual average (2000 – 2006) application of biosolids within the study area of 400 dry tons (2.25E+13 cfu/yr), provided by HRSD.
2. For TMDL comparison, PASTURE also includes LIVESTOCK ACCESS.
3. The DIRECT WILDLIFE source represents nutria.

DISCUSSION

Hydrologic Simulation Program – Fortran (HSPF) was used to simulate fecal coliform loading to Nanney Creek from the contributing watershed. Annual fecal coliform loads to the model (7.80E+14 cfu) were almost 40% greater than the existing conditions loads used for TMDL development (5.64E+14 cfu). Major sources of bacteria from the watershed include livestock (59%) and wildlife (34%). Direct human contributions through failing or malfunctioning septic tanks and uncontrolled discharges represents less than 1% of the total existing load to Nanney Creek.

Currently, hogs are the single largest bacterial contributor in the watershed (29%). However, according to local farmers, the hog population is being removed from the watershed shortly. Once this occurs, wildlife will become the largest source of bacteria from the watershed (48%); livestock will then contribute 41%.

REFERENCE

MapTech, Inc. April 2005. *Development of Bacterial TMDLs for the Virginia Beach Coastal Area (London Bridge Creek & Canal # 2, Milldam Creek, Nawney Creek, West Neck Creek (Middle), and West Neck Creek (Upper)*. Prepared for the Virginia Department of Environmental Quality.

ATTACHMENT A – CALIBRATION RESULTS

Figure 1. Simulated vs. Observed FC Concentrations at VDEQ Station 5BNWN001.84, 2003

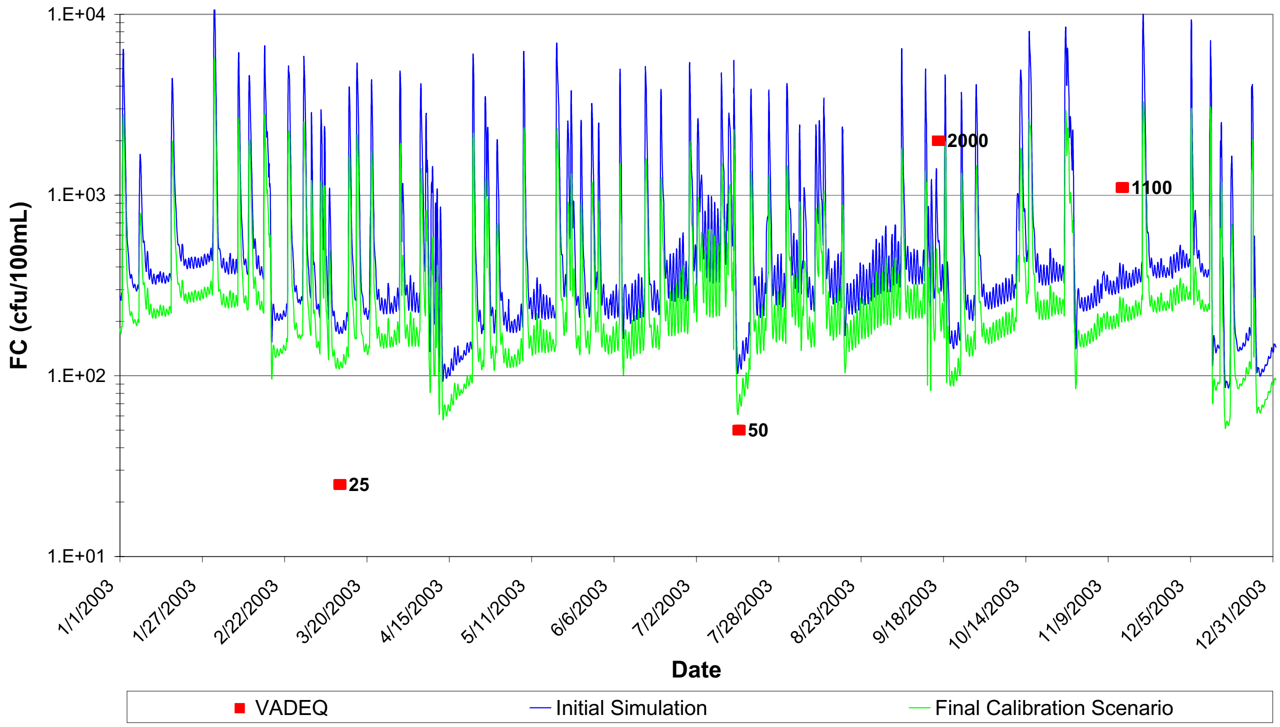


Figure 2. Simulated vs. Observed FC Concentrations at VDEQ Station 5BNWN001.84, 2004

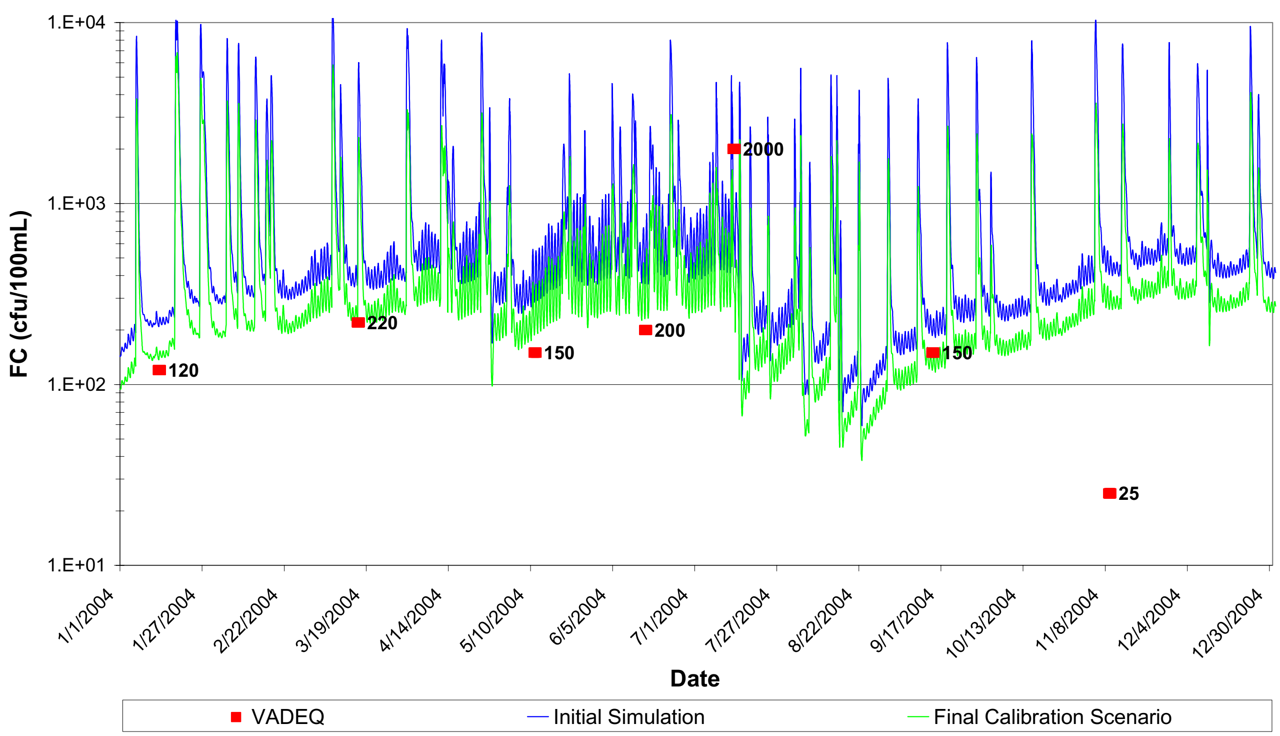


Figure 3. Simulated vs. Observed FC Concentrations at VDEQ Station 5BNWN001.84, 2005

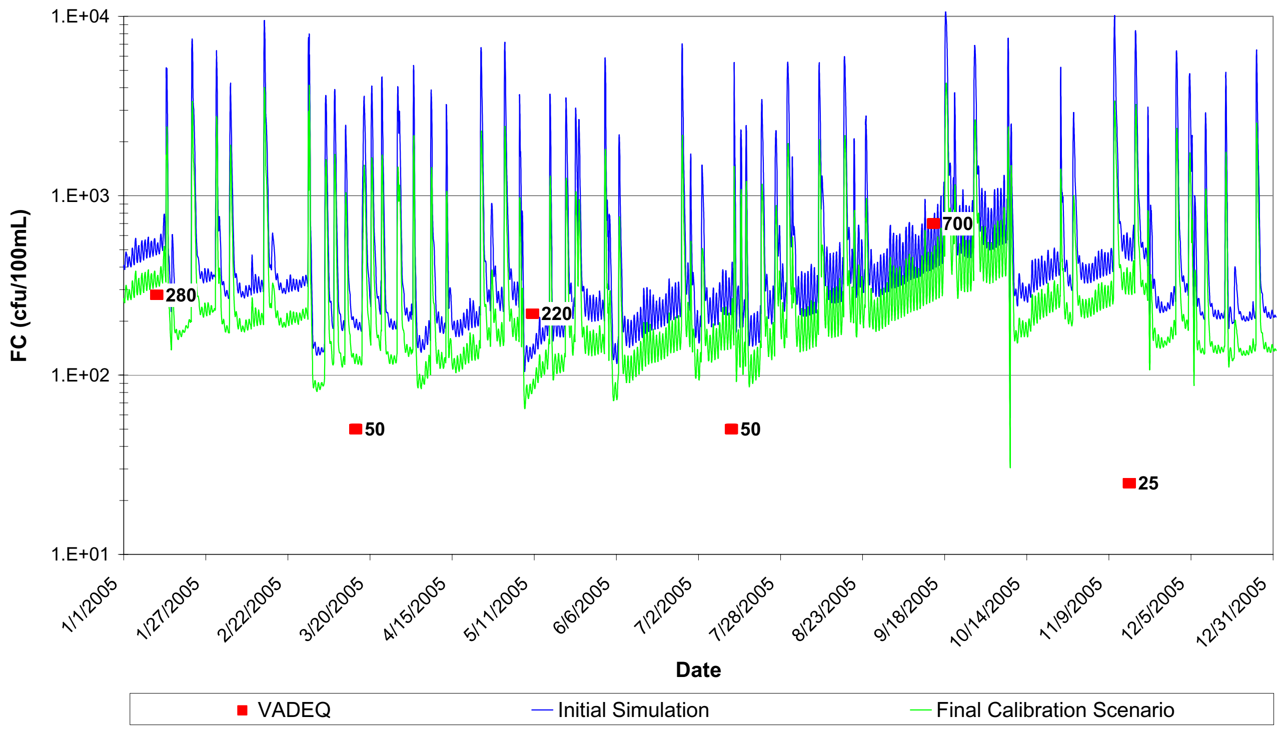


Figure 4. Simulated vs. Observed FC Concentrations at VDEQ Station 5BNWN001.84, 2006

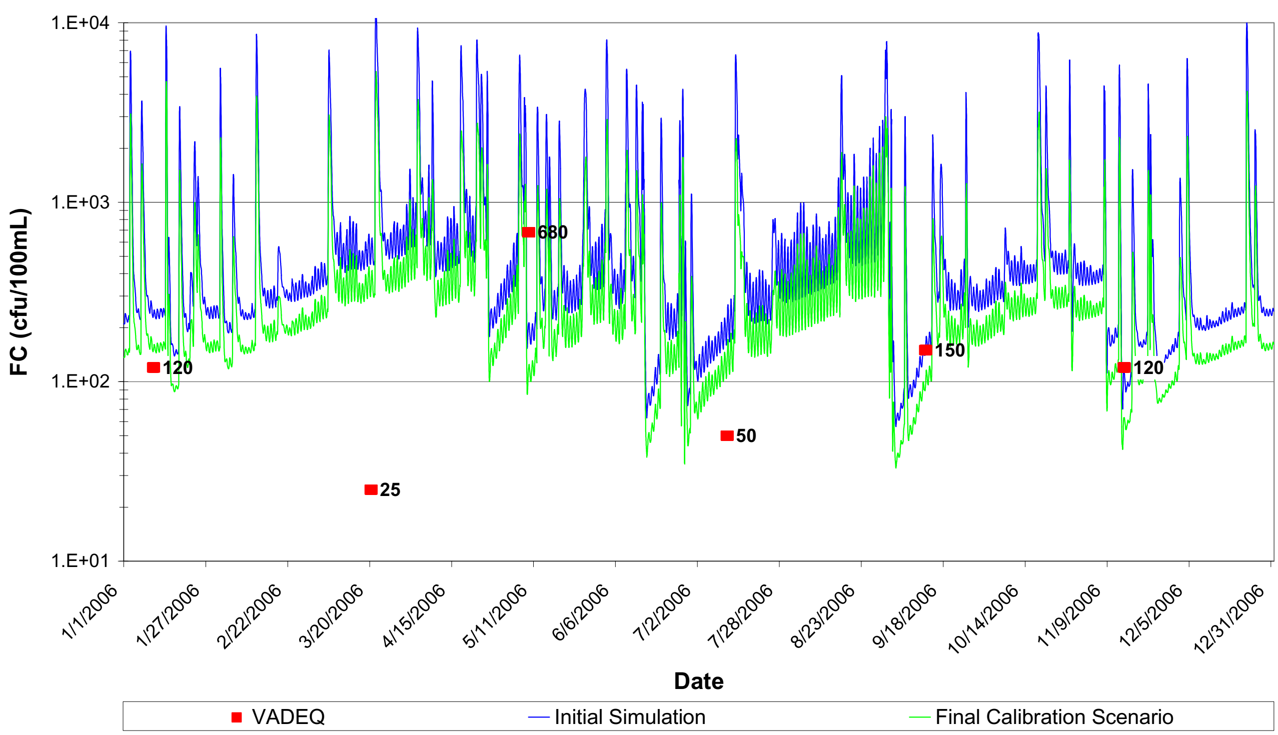


Figure 5. Simulated vs. Observed FC Concentrations at VDEQ Station 5BNWN000.00, 2003

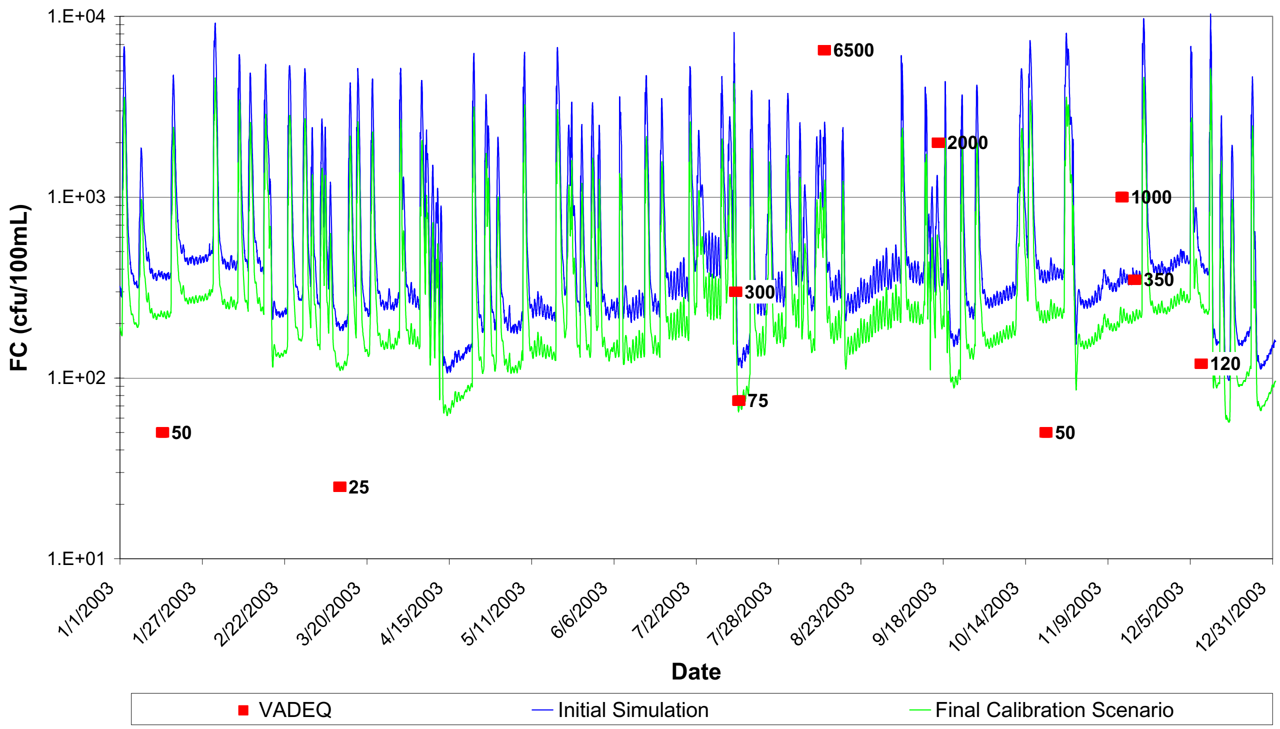


Figure 6. Simulated vs. Observed FC Concentrations at VDEQ Station 5BNWN000.00, 2004

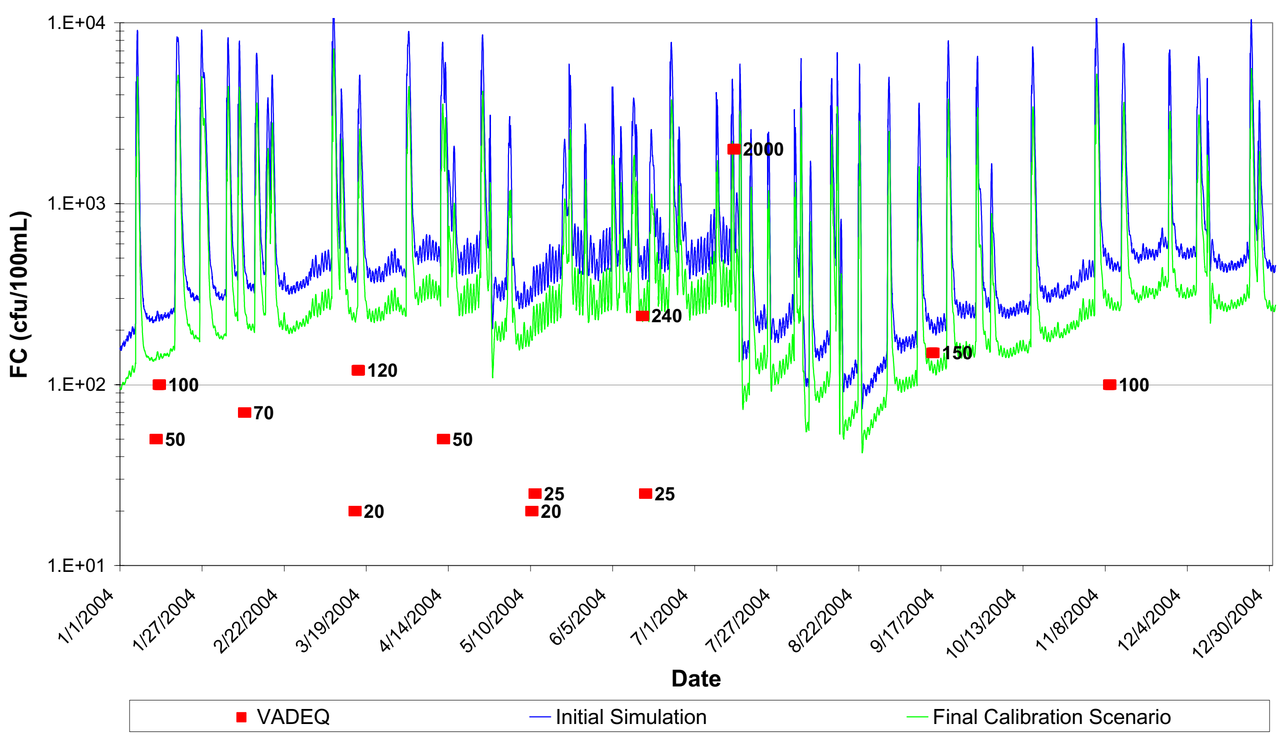


Figure 7. Simulated vs. Observed FC Concentrations at VDEQ Station 5BNWN000.00, 2005

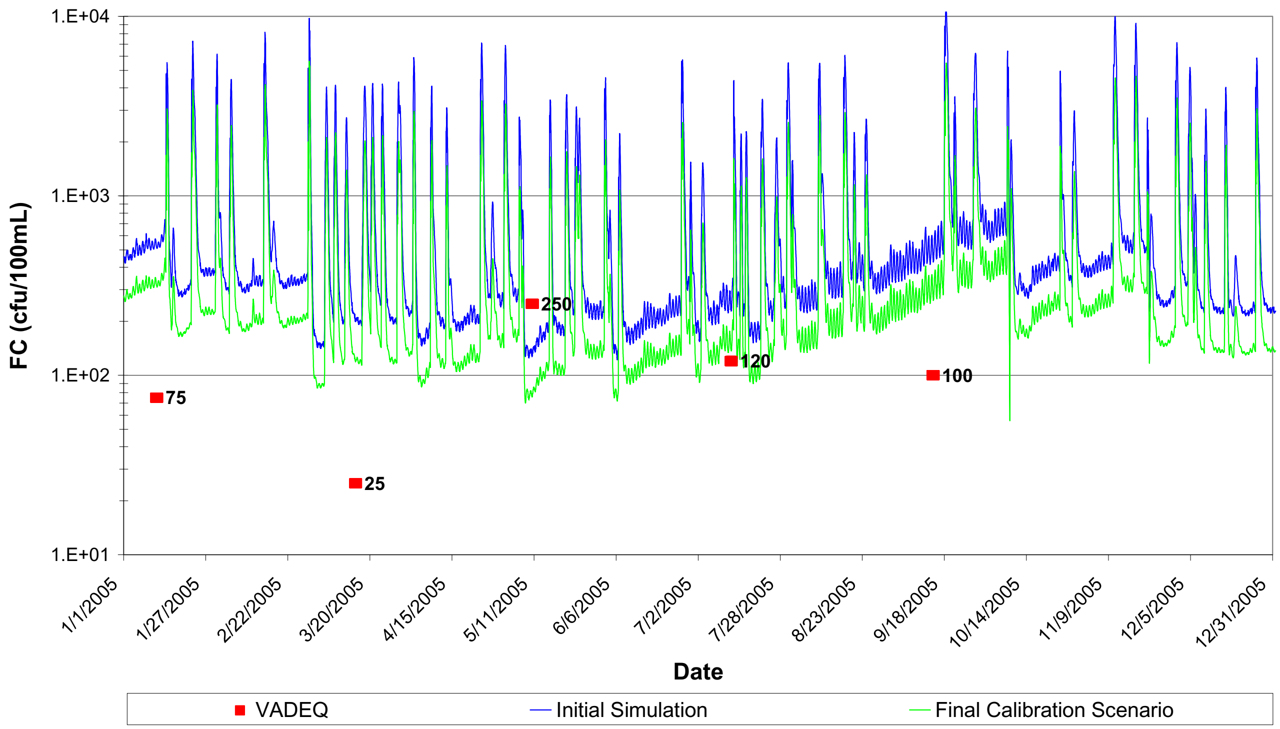
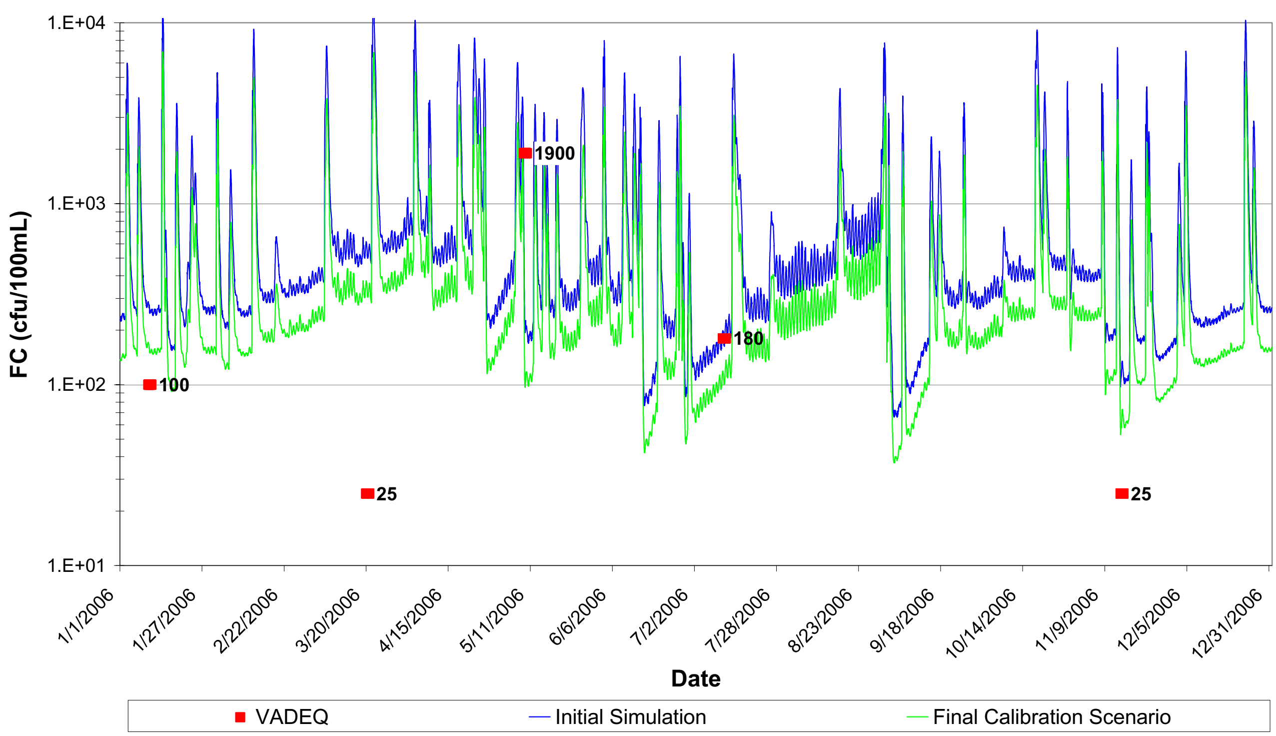


Figure 8. Simulated vs. Observed FC Concentrations at VDEQ Station 5BNWN000.00, 2006



ATTACHMENT B – SOURCE REPRESENTATION

Table. Nonpoint Sources of Fecal Coliform Applied to Land Use Categories, Existing Conditions

Land Use Category	WILDLIFE								LIVESTOCK						HUMAN & PET	
	DEER	DUCK		GOOSE	GULL	MUSKRAT	RACCOON		CATTLE	GOATS	HORSES	HOGS	MANURE	SHEEP	BIOSOLIDS	DOG
		PRIMARY	*SECONDARY*				*PRIMARY*	*SECONDARY*								
COMMERCIAL																
B-----	X		X					X								
BAG-----	X		X					X								X
BAG-----A16	X		X					X							X	X
BAG----H-	X		X					X			X					X
BAG-----P4	X		X					X								X
BAG-R----	X	X					X									X
BAG-R---H-	X	X					X				X					X
B----H-	X		X					X			X					
CH-----	X		X					X								
CH----H-	X		X					X			X					
CH-R---H-	X	X					X				X					
CM-----	X		X					X								
CM----D-	X		X					X								
DR-----	X		X					X								
DR-R----	X	X					X									
O-----	X		X					X								
O-R----	X	X					X									
SC-----	X		X					X								
SC-R----	X	X					X									
CROPLAND																
AGC-----	X		X	X	X			X					X			
AGC--1---	X		X	X	X	X		X					X			
AGC--1---A10	X		X	X	X	X		X					X		X	
AGC--1---A11	X		X	X	X	X		X					X		X	
AGC--1---A12	X		X	X	X	X		X					X		X	
AGC--1---A14	X		X	X	X	X		X					X		X	
AGC--1---A15	X		X	X	X	X		X					X		X	
AGC--1--H-	X		X	X	X	X		X			X		X			
AGC--1--P-	X		X	X	X	X		X				X	X			
AGC--1---P3	X		X	X	X	X		X					X			
AGC--1---P5	X		X	X	X	X		X					X			
AGC--1--P-A2	X		X	X	X	X		X				X	X		X	
AGC--1--P-A3	X		X	X	X	X		X				X	X		X	
AGC--1--P-A4	X		X	X	X	X		X				X	X		X	
AGC---2--	X		X	X	X	X		X					X			

Land Use Category	WILDLIFE								LIVESTOCK						HUMAN & PET	
		DUCK					RACCOON									
	DEER	*PRIMARY*	*SECONDARY*	GOOSE	GULL	MUSKRAT	*PRIMARY*	*SECONDARY*	CATTLE	GOATS	HORSES	HOGS	MANURE	SHEEP	BIOSOLIDS	DOG
AGC---2--A1	X		X	X	X	X		X					X		X	
AGC---2--A2	X		X	X	X	X		X					X		X	
AGC---2--A3	X		X	X	X	X		X					X		X	
AGC---2--A6	X		X	X	X	X		X					X		X	
AGC---2--A7	X		X	X	X	X		X					X		X	
AGC---2-H-	X		X	X	X	X		X			X		X			
AGC---2--P2	X		X	X	X	X		X					X			
AGC---2-S-	X		X	X	X	X		X					X	X		
AGC-----A13	X		X	X	X			X					X		X	
AGC-----A16	X		X	X	X			X					X		X	
AGC-----A3	X		X	X	X			X					X		X	
AGC-----A6	X		X	X	X			X					X		X	
AGC-----A8	X		X	X	X			X					X		X	
AGC-----A9	X		X	X	X			X					X		X	
AGC----H-	X		X	X	X			X			X		X			
AGC----HD-	X		X	X	X			X			X		X			
AGC-----P1	X		X	X	X			X					X			
AGC-----P4	X		X	X	X			X					X			
AGC-R----	X	X		X	X		X						X			
AGC-R-1---	X	X		X	X	X	X						X			
AGC-R-1---A10	X	X		X	X	X	X						X		X	
AGC-R-1---A11	X	X		X	X	X	X						X		X	
AGC-R-1---A14	X	X		X	X	X	X						X		X	
AGC-R-1---A15	X	X		X	X	X	X						X		X	
AGC-R-1--H-	X	X		X	X	X	X				X		X			
AGC-R-1--P-	X	X		X	X	X	X					X	X			
AGC-R-1---P3	X	X		X	X	X	X						X			
AGC-R-1---P5	X	X		X	X	X	X						X			
AGC-R-1--P-A3	X	X		X	X	X	X					X	X		X	
AGC-R-1--P-A4	X	X		X	X	X	X					X	X		X	
AGC-R-1--P-A5	X	X		X	X	X	X					X	X		X	
AGC-R--2--	X	X		X	X	X	X						X			
AGC-R--2--A1	X	X		X	X	X	X						X		X	
AGC-R--2--A2	X	X		X	X	X	X						X		X	
AGC-R--2--A3	X	X		X	X	X	X						X		X	
AGC-R--2--A5	X	X		X	X	X	X						X		X	
AGC-R--2--A7	X	X		X	X	X	X						X		X	
AGC-R--2-H-	X	X		X	X	X	X				X		X			
AGC-R--2-S-	X	X		X	X	X	X						X	X		
AGC-R----A3	X	X		X	X		X						X		X	

Land Use Category	WILDLIFE								LIVESTOCK						HUMAN & PET	
		DUCK					RACCOON									
	DEER	*PRIMARY*	*SECONDARY*	GOOSE	GULL	MUSKRAT	*PRIMARY*	*SECONDARY*	CATTLE	GOATS	HORSES	HOGS	MANURE	SHEEP	BIOSOLIDS	DOG
AGC-R----A5	X	X		X	X		X						X		X	
AGC-R----A8	X	X		X	X		X						X		X	
AGC-R----A9	X	X		X	X		X						X		X	
AGC-R---C-	X	X		X	X		X		X				X			
AGC-R---H-	X	X		X	X		X				X		X			
AGC-R---HD-	X	X		X	X		X				X		X			
AGC-R----P1	X	X		X	X		X						X			
PASTURE																
AGF-----	X		X					X								
AGF-R----	X	X					X									
AGO-R---H-	X	X					X				X					
AGP-----	X		X					X								
AGP----C-	X		X					X	X							
AGP----H-	X		X					X			X					
AGP----HG-	X		X					X		X						
AGP-R----	X	X					X									
AGP-R---C-	X	X					X		X							
AGP-R---G-	X	X					X			X						
AGP-R---H-	X	X					X				X					
AGP----SH-	X		X					X			X			X		
RESIDENTIAL																
SFH-----	X		X					X								X
SFL-----	X		X					X								X
SFL----C-	X		X					X	X							X
SFL----D-	X		X					X								X
SFL----H-	X		X					X			X					X
SFL----HG-	X		X					X		X	X					X
SFL----HP-	X		X					X			X	X				X
SFL-----P3	X		X					X								X
SFL-----P5	X		X					X								X
SFL-R----	X	X					X									X
SFL-R---C-	X	X					X		X							X
SFL-R---D-	X	X					X									X
SFL-R---G-	X	X					X			X						X
SFL-R---H-	X	X					X				X					X
SFL-R---HD-	X	X					X				X					X
SFL-R---HG-	X	X					X			X	X					X
SFL-R----P3	X	X					X									X
SFL-R----P5	X	X					X									X

Land Use Category	WILDLIFE								LIVESTOCK						HUMAN & PET	
		DUCK					RACCOON									
	DEER	*PRIMARY*	*SECONDARY*	GOOSE	GULL	MUSKRAT	*PRIMARY*	*SECONDARY*	CATTLE	GOATS	HORSES	HOGS	MANURE	SHEEP	BIOSOLIDS	DOG
SFL----SH-	X		X					X			X			X		X
SFM-----	X		X					X								X
SFM-R----	X	X					X									X
SFM-R---H-	X	X					X				X					X
STREETS (INCLUDING RIGHT-OF-WAY)																
ST-----	X		X													
ST-R----	X		X													
ST-R---HD-	X		X													
WATER																
BMP-----																
BMP-R----																
WAT-----																
WETLANDS																
WT-----	X	X		X				X								
WT-R----	X	X		X			X									
WT-R---H-	X	X		X			X				X					
WOODLANDS																
UND-----	X		X	X				X								
UND----GH-	X		X	X				X		X	X					
UND----H-	X		X	X				X			X					
UND-R----	X	X		X			X									
UND-R---H-	X	X		X			X				X					
UND-R---HD-	X	X		X			X				X					
WD-----	X		X					X								
WD---2-H-	X		X			X		X			X					
WD-----A11	X		X					X							X	
WD-----A15	X		X					X							X	
WD-----A4	X		X					X							X	
WD----GH-	X		X					X		X	X					
WD----H-	X		X					X			X					
WD-----P1	X		X					X								
WD-----P3	X		X					X								
WD-R----	X	X					X									
WD-R----A11	X	X					X								X	
WD-R----A15	X	X					X								X	
WD-R----A3	X	X					X								X	
WD-R---H-	X	X					X				X					
WD-R----P5	X	X					X									

TECHNICAL MEMORANDUM
SEPTIC SYSTEM LOADING AND IMPACT – NANNEY CREEK BASIN

Prepared for: City of Virginia Beach, Virginia
Department of Public Works

Prepared by: URS Corporation
Virginia Beach, Virginia

Date: Submitted March 31, 2008

Contract: PWCN-6-0026
Work Order 13A – Water Quality Model for Nanney Creek Basin
URS Project No. 11657119

PURPOSE

Hydrologic Simulation Program – Fortran (HSPF) has often been used in the Total Maximum Daily Load (TMDL) development process to establish load and waste load allocations associated with land-based constituent loading to impaired waters. However, HSPF can also be a useful tool to aid in developing public assistance programs as part of TMDL implementation. In this case, the impact of septic system discharges to Nanney Creek has been estimated and used to provide guidance in developing a septic pump-out program. HSPF scenarios were performed to simulate fecal coliform concentrations in segments of Nanney Creek due to the septic loads in the absence of any other land-based loads. A septic system database for the study area was developed that provides system age and location data. Relevant, yet limited, Virginia Department of Environmental Quality (VADEQ) water quality observations and bacterial source tracking (BST) data were used as targets when estimating existing fecal coliform loadings to Nanney Creek. Literature values based on septic system age were used to project future conditions in the creek due to progressive septic system failures. Results of the HSPF simulations provide the estimated number of septic tanks currently contributing bacteria to the creek through system failure. Focus areas for program implementation as well as planning-level costs have also been established.

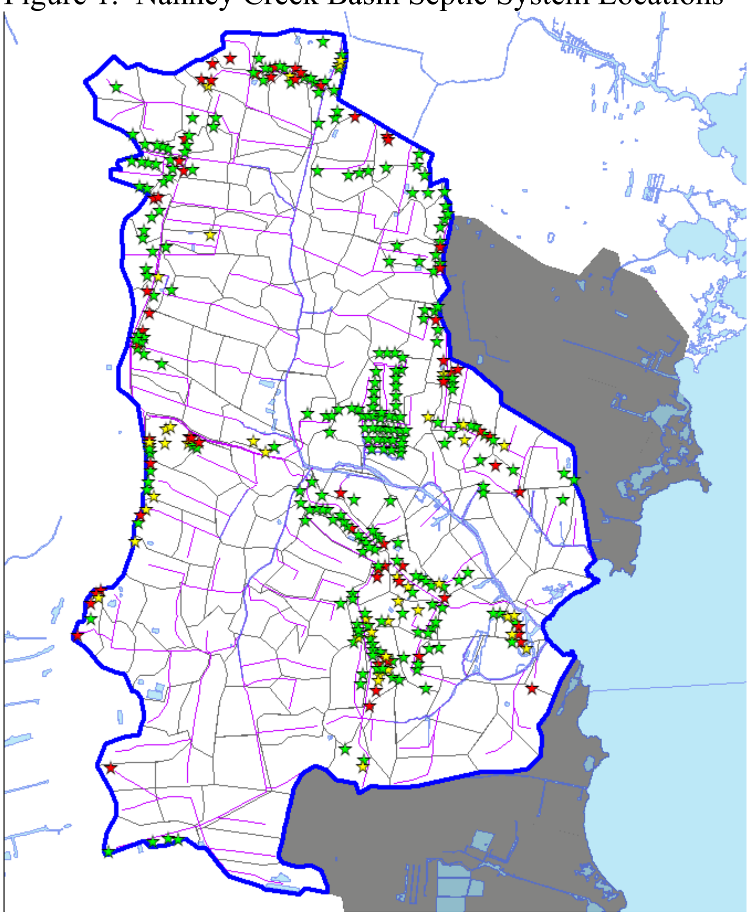
METHODOLOGY

Preliminary HSPF simulations using literature values for septic system failure rates based on system age resulted in in-stream fecal coliform concentrations higher than observed values. Therefore, in order to estimate the current septic contributions (as the number of currently failing septic systems) to fecal coliform concentrations in Nanney Creek, the number and location of systems as well as the maximum bacterial load for each septic were determined. Fecal coliform concentrations and BST results at relevant water quality monitoring locations in Nanney Creek were used to estimate the portion of bacteria originating from human, or septic, sources. Multiple failure rate scenarios were performed using HSPF until simulated fecal coliform concentrations agreed with the portion of observed values believed to be of human origin.

SEPTIC SYSTEM IDENTIFICATION

Public sanitary facilities have not been extended to southern Virginia Beach, and the entirety of the study area relies on private sewerage systems. As a part of the overall modeling effort, a database of septic systems in the Virginia Beach Watershed 24 was developed. Applications by Virginia Beach residents for new private septic systems or requests for modifications to existing systems were provided in database format by the Virginia Department of Health (VDH). Using the provided attribute data and best engineering judgment (BEJ), records meeting the following criteria were retained for inclusion in the Watershed 24 septic system database: (1) address within the study area; and, (2) application NOT denied (many database entries had no recorded approval date, but were not denied). Retained records were then compared to land use information gathered as a part of the modeling effort (see Technical Memorandum – Drainage Pattern Determination & Land Use Development). The Watershed 24 septic system database was supplemented with additional septic system records for parcels identified as commercial establishments or having one or more homesteads and not represented by retained VDH data. Figure 1 provides a graphical depiction of septic system locations in the Nanney Creek Basin within Watershed 24. A total of 352 systems were identified.

Figure 1. Nanney Creek Basin Septic System Locations



SEPTIC SYSTEM LOADING

An average of 2.7 persons per system (US Census Bureau, 2000) and an average daily flow of 75 gallons per day per person (VDH, 2000) were used to develop the average daily flow per septic system. The last column of the table represents the maximum available daily fecal coliform load from each septic system.

Table 1. Development of Septic Fecal Coliform Loads (cfu/septic-day)

Persons per System	Avg Daily Flow (gpd/person)	Avg Daily Flow (gpd/septic)	FC Concentration (cfu/100mL)	FC Load (cfu/septic-day)
2.7	75	202.5	1.04E+06	**7.97E+08**

RELEVANT WATER QUALITY OBSERVATIONS

There are two (2) VADEQ water quality monitoring stations along Nanney Creek. Nanney Creek stations 5BNWN001.84 and 5BNWN000.00, as well as the segments of Nanney Creek impaired for bacteria, are shown in Figure 2. Fecal coliform concentrations recorded at each of these stations for the period 2003 through 2006 are shown in Table 2 below. Additional bacterial enumerations and bacterial source tracking were performed at the mouth of Nanney Creek (station 5BNWN000.00) in conjunction with development of the bacterial TMDL for Nanney Creek. Those data are also presented in Table 2.

Figure 2. VADEQ Water Quality Monitoring Stations for Nanney Creek

Table 2. Nanney Creek Fecal Coliform and BST Data, 2003 – 2006

Collection Date	5BNWN000.00 (Nawney Creek Lower)			5BNWN001.84 (Nawney Creek Upper)	
	FC (cfu/100mL)	Code	BST (% human)	FC (cfu/100mL)	Code
01/14/03	50				
03/11/03	25			25	
07/14/03	300		**0**		
07/15/03	75			50	
08/11/03	6500		**0**		
09/16/03	2000	L		2000	L
10/20/03	50		**0**		
11/13/03	1000			1100	
11/17/03	350		**0**		
12/08/03	120		**25**		
01/12/04	50		**25**		
01/13/04	100			120	
02/09/04	70		**0**		
03/15/04	20		**10**		
03/16/04	120			220	
04/12/04	50		**38**		
05/10/04	20		**50**		
05/11/04	25	U		150	
06/14/04	240		**0**		
06/15/04	25			200	
07/13/04	2000	L		2000	L
09/14/04	150			150	
11/09/04	100			25	U
01/11/05	75			280	
03/15/05	25			50	
05/10/05	250			220	
07/12/05	120			50	
09/14/05	100			700	
11/15/05				25	
01/10/06	100			120	
03/20/06	25			25	U
05/09/06	1900			680	
07/11/06	180			50	
09/12/06				150	
11/14/06	25	U		120	

Code L – Off-Scale High / Actual Value Not Shown (Value is known to be greater than value shown.)
Code U – Material Analyzed For, But Not Detected (Value stored is the limit of detection.)

No evident relationship was identified between the BST results and fecal coliform concentrations. There is also no relevant flow data available to associate with the bacterial concentration or BST data. Therefore, for the purpose of this evaluation, the portion of bacteria originating from human sources was estimated as the average of the BST percent human values, or **13.5%**.

HSPF Simulations

Septic tank contributions were represented as point source loads in the HSPF model, and the daily coliform load for each subbasin in the watershed was input as a time series (cfu/day) directly to each subbasin stream. Septic tank contributions also include flow time series (L/day) as input. Input from area residents suggests that flow in portions of Nanney Creek is reduced due to stream blockages. In the absence of additional data, it was assumed that allowable outflow from creek segments is restricted to 70% of unblocked conditions. For additional information pertaining to HSPF set up and parameters, see Technical Memorandum – Drainage Pattern Determination & Land Use Development and Draft Technical Memorandum – Fecal Coliform Loading.

Output timeseries for flow and fecal coliform concentrations were specified for the mouth of Nanney Creek for the period 2003 through 2006. Septic system load inputs were varied until simulated concentrations showed relative agreement with the "human portion" of VADEQ monitoring data.

Existing Conditions Results

The figures below depict simulated in-stream fecal coliform concentrations resulting from septic leakage rates of ten percent (10%) and one percent (1%) of the total 352 septic systems in the Nanney Creek Basin.

Figure 3. 2003 Simulated vs. Observed Fecal Coliform Concentrations – Mouth of Nanney Creek

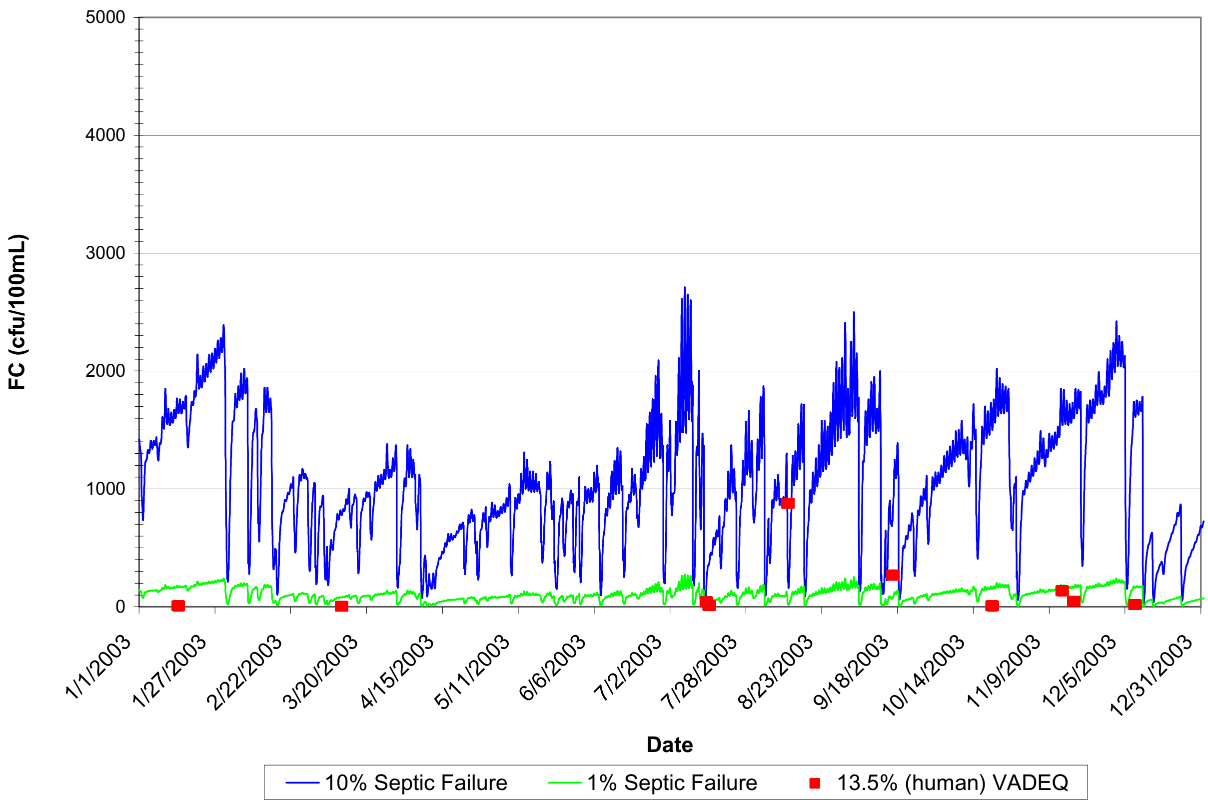


Figure 4. 2004 Simulated vs. Observed Fecal Coliform Concentrations – Mouth of Nanney Creek

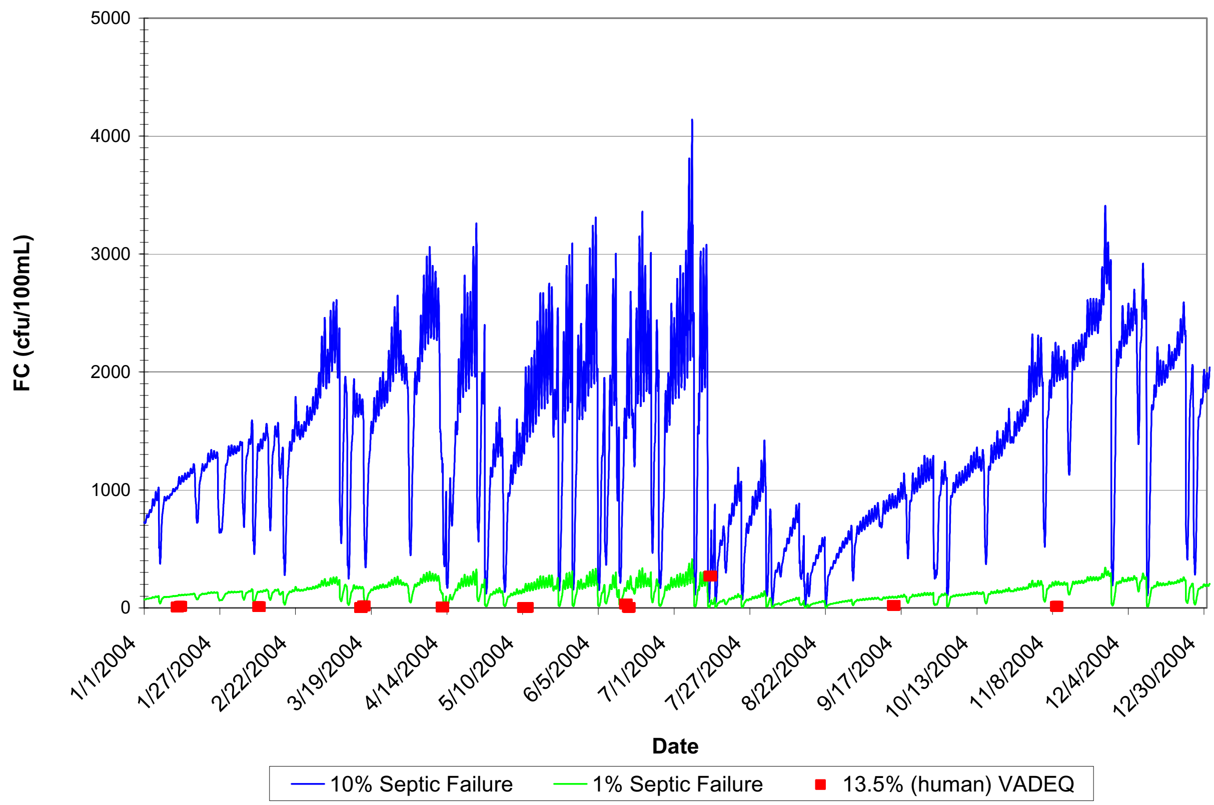


Figure 5. 2005 Simulated vs. Observed Fecal Coliform Concentrations – Mouth of Nanney Creek

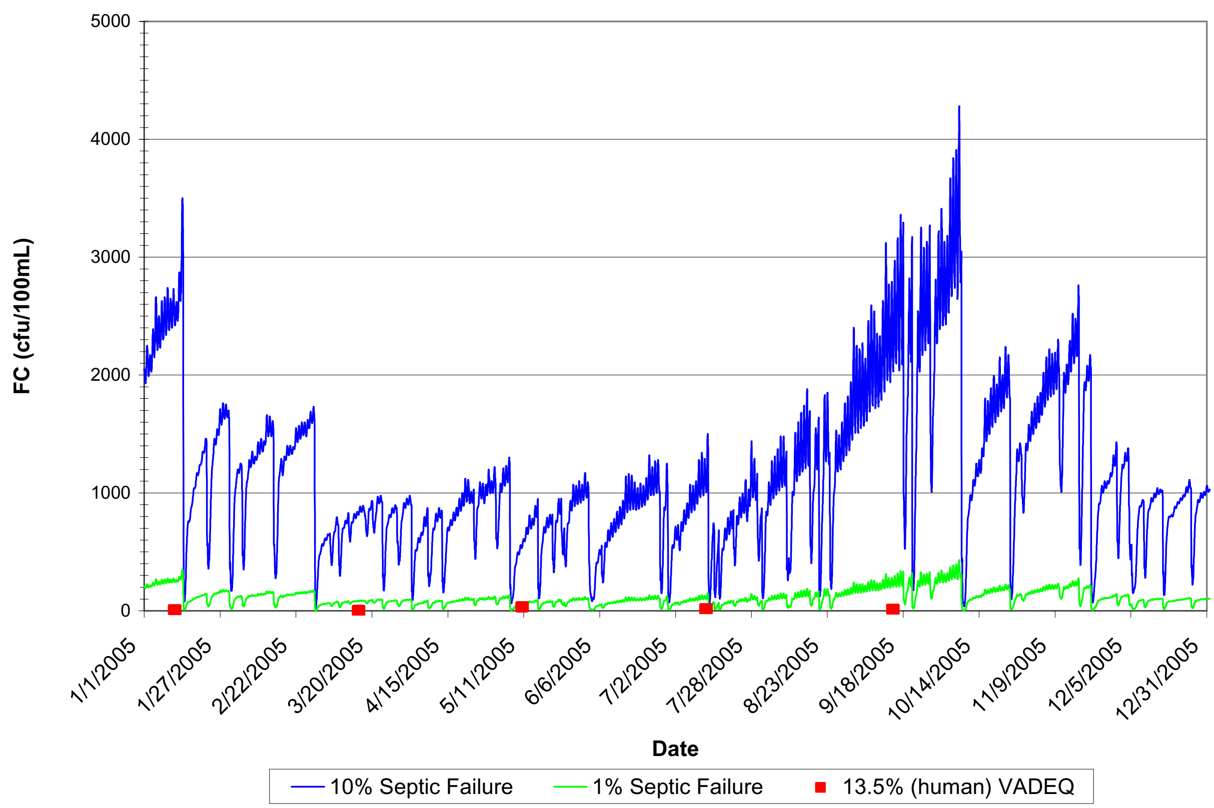
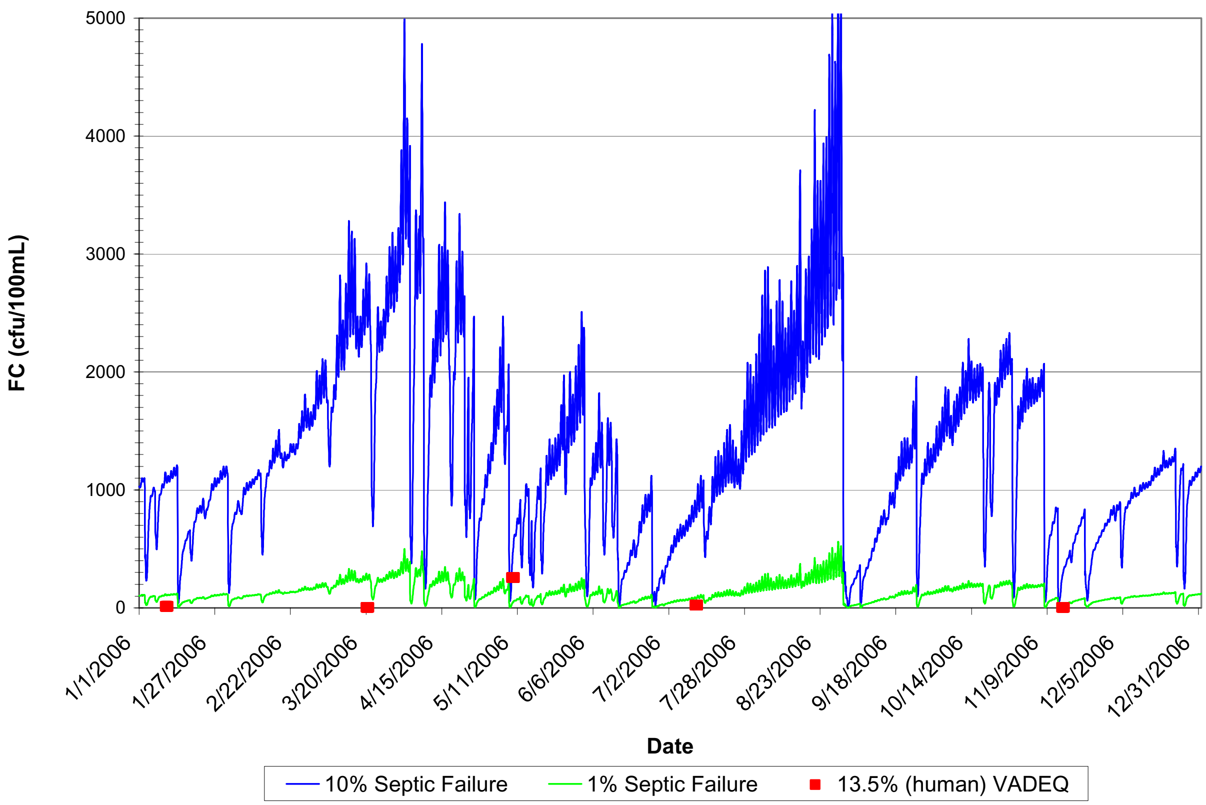


Figure 6. 2006 Simulated vs. Observed Fecal Coliform Concentrations – Mouth of Nanney Creek



It is apparent from the previous figures that a 1% septic system failure rate provides general agreement with the estimated "human portion" of the observed monitoring data. One percent (1%) of the system equates to approximately four (4) septic systems if the systems were discharging directly to Nanney Creek. However, a more realistic equivalent load would likely be produced by 5% – 10% of the systems since the septic effluent flows through the soil prior to reaching the creek. Ten percent (10%) of the system equates to approximately thirty-five (35) septic systems. This is the best conservative estimate of current conditions using all relevant, available information.

ANTICIPATED FUTURE CONDITIONS

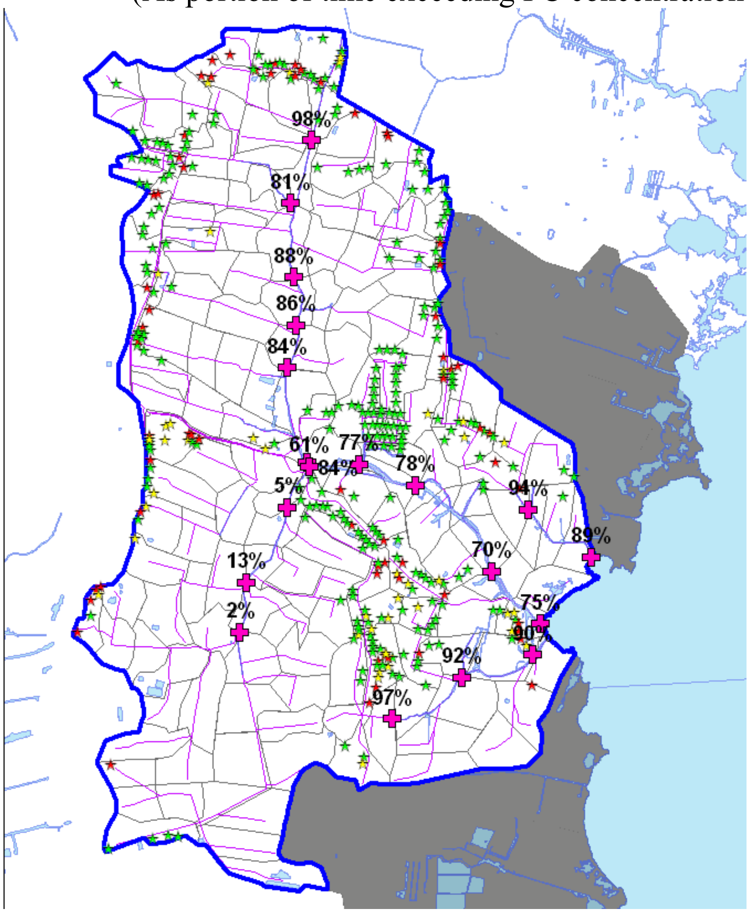
Although not representative of current septic loading conditions, published failure rates based on system age were used to represent anticipated future conditions within the watershed if maintenance and service of existing septic systems is not addressed. The septic system failure rates were estimated based on the age of the septic system (MapTech, 2005) as shown in Table 3. The fecal coliform concentration in septic tank effluent was multiplied by the estimated septic leakage rate to determine the total load from each failing system.

Table 3. Development of Future Septic Fecal Coliform Loads (cfu/septic-day)

Septic System Installation Year	Failure Rate (%)	Avg Daily Flow (gpd/septic)	Septic Leakage (gpd/septic)	FC Concentration (cfu/100mL)	FC Load (cfu/septic-day)
Prior to 1964	40	202.5	81	1.04E+06	**3.19E+09**
1964 – 1984	20	202.5	40.5	1.04E+06	**1.59E+09**
1985 – Current	5	202.5	10.125	1.04E+06	**3.99E+08**

Figure 7 presents the portion of hourly output fecal coliform concentrations exceeding 1000 cfu/100mL. This value represents the applicable instantaneous fecal coliform water quality standard (WQS) prior to January 2003. There is no data to indicate that septic system failure rates will not achieve these documented levels if no action is taken to prevent it.

Figure 7. Anticipated Nanney Creek Conditions due to Septic System Failures
(As portion of time exceeding FC concentration of 1000 cfu/100mL)



RECOMMENDATIONS

In order to improve Nanney Creek water quality and avoid the eventual failure of unmaintained septic systems, URS recommends a three-pronged approach: education, action, and evaluation.

PUBLIC EDUCATION

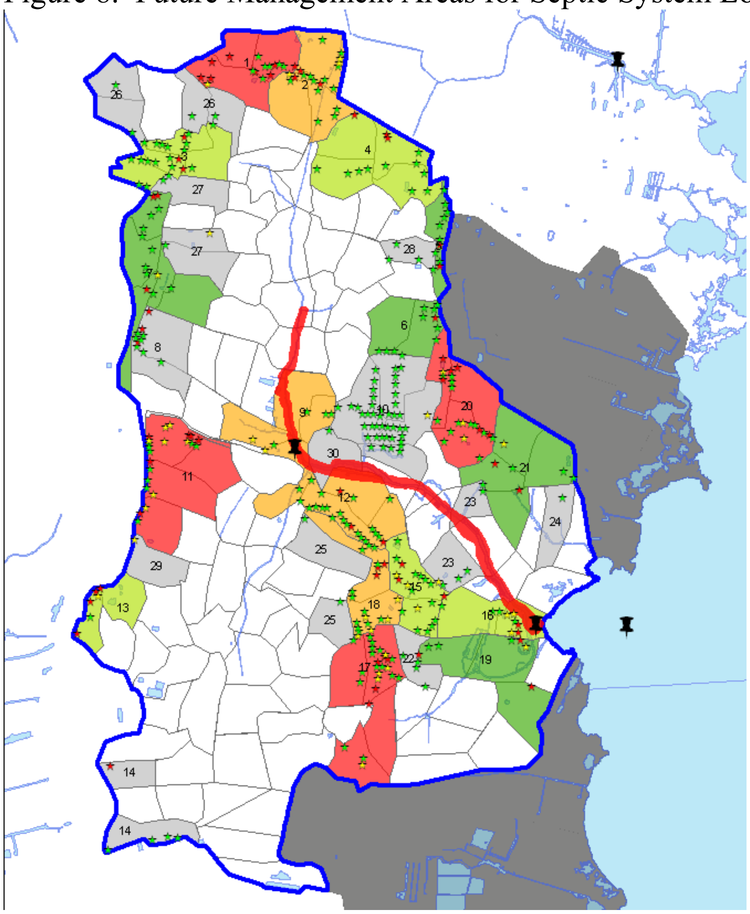
First, it is recommended that the City conduct a workshop to educate area residents on proper septic system maintenance.

SEPTIC PUMP – OUT PROGRAM

Based on the calibrated HSPF simulation for existing septic loading conditions and using BEJ, up to thirty-five (35) septic systems are currently in need of service. URS recommends that the City develop and implement a septic pump-out program to assist the public with the costs associated with proper maintenance of their septic systems.

Clusters of septic systems were identified by location within the study area and proximity to the creek. Based on anticipated future septic loading conditions, model scenarios were performed to simulate the effects of a septic pump-out program. The HSPF model was used to identify and prioritize septic system clusters according to their potential to adversely affect Nanney Creek water quality. Figure 8 presents future management areas within the Nanney Creek Basin. Eventual septic system failures in these areas will have the greatest impact on increased fecal coliform concentrations in Nanney Creek. The areas of highest priority are shown in red.

Figure 8. Future Management Areas for Septic System Load Mitigation



Associated Costs

In order to estimate the costs associated with implementation of a septic pump-out program, URS contacted ten (10) local merchants that provide septic services. Information collected is presented below in Table 4. Based on the companies contacted as a part of this effort, the average price for a septic tank pump-out of 1000 gallons is $216. The cost associated with providing pump-out services to the estimated thirty-five (35) systems currently experiencing some form of septic system failure is $7560. This figure is based on pump-out services only. Additional – and potentially high – costs would be associated with other rehabilitation services to restore proper septic system function. URS also recommends that general inspections be performed as a part of the pump-out program. The average cost of a septic system inspection is $266. Some companies include the cost of pumping out the septic system when an inspection is requested.

Table 4. Local Septic Tank Service Pricing Information

Company Name (DBE/SWAM)	Contact Information	Pricing Information General Inspection	Pump Out (0-1000 gal)	Notes
Budget Septic Systems	Virginia Beach, VA 757-422-3100	$290	$215 $0.215 for each add'l gal	Other service charges vary.
C.S. Hines Inc / Addenbrook Septic Tank Contractors (SWAM)	1828 Mount Pleasant Rd Chesapeake, VA 757-546-1473	NA	$215	Other service charges vary.
B. Ray Hines LLC	808 Land of Promise Rd Chesapeake, VA 757-421-3821	NA	$210	Other service charges vary.
Mdm Septic Service Inc	1400 Campbells Landing Rd Virginia Beach, VA 757-426-0511	NA	$195	Other service charges vary.
E.W. Brown Plumbing and Heating	4110 Bainbridge Blvd Chesapeake, VA 757-545-1832	$290	$215	Pump-out most likely provided with general inspection.
Forrest Septic Tank Co	5015 Bainbridge Blvd Chesapeake, VA 757-543-6100	UNK	UNK	Recommended for additional services. Waiting for call back.
Z Artis Septic Tank Service	2756 Battlefield Blvd Chesapeake, VA 757-421-4981	NA	$205	Other service charges vary.
Rabb Septic Tank Cleaning Service	1829 Nansemond Pkwy Suffolk, VA 757-538-0588	$125	$250	General inspection probably does not include pump-out.
Ledbetter Linwood R-Rillco	122 Bell St Suffolk, VA 757-539-2003	$360	$225	Pump-out provided with general inspection.

NA – Information not available from point of contact.

FOLLOW – UP SAMPLING PROGRAM

URS recommends that the City perform intensive bacterial sampling in Nanney Creek to: (1) identify additional "focus areas" for future implementation programs and to for future within the watershed; and, (2) to gauge the effects of the septic pump-out program on water quality in Nanney Creek. Sampling program development is beyond the scope of the current effort.

CONCLUSIONS

Of the 352 septic systems identified in the Nanney Creek Basin, up to 10% or approximately thirty-five (35) systems are believed to be discharging untreated septic tank effluent to Nanney Creek. Though this is a small portion of systems, the affect on in-stream fecal coliform concentrations is substantial. Development and implementation of a septic pump-out program along with education and follow-up sampling will improve water quality and help to avoid future water quality degradation.

REFERENCES

BASINS 3.1 (BASINSa). *BASINS/HSPF Training Appendix F – Manually Adding Temperature and Fecal Coliform.*

BASINS 3.1 (BASINSb). *pollutants.txt.* Located in the BASINS 3.1 software download at BASINS\models\HSPF\bin.

MapTech, Inc. April 2005. *Development of Bacterial TMDLs for the Virginia Beach Coastal Area (London Bridge Creek & Canal # 2, Milldam Creek, Nawney Creek, West Neck Creek (Middle), and West Neck Creek (Upper)*. Prepared for the Virginia Department of Environmental Quality.

URS Corporation (URS). February 2007. *Technical Memorandum – Historic Water Quality Monitoring Data Evaluation.* Prepared for the City of Virginia Beach Department of Public Works.

URS Corporation (URS). December 2007. *Technical Memorandum – Drainage Pattern Determination & Land Use Development.* Prepared for the City of Virginia Beach Department of Public Works.

URS Corporation (URS). February 2008. *Draft Technical Memorandum – Fecal Coliform Loading* Prepared for the City of Virginia Beach Department of Public Works.

US Census Bureau. 2000. *Quick Facts, Virginia Beach City, Virginia.* http://quickfacts.census.gov/qfd/states/51/51810.html

U.S. Environmental Protection Agency (USEPA). January 2001. *Protocol for Developing Pathogen TMDLs.* EPA 841-R-00-002. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

Virginia Beach Code of Ordinances. 2007. *Zoning Ordinance.*http://www.municode.com/Resources

Virginia Department of Health (VDH). July 2000. *Sewage Handling and Disposal Regulations.* 12VAC5-610-670. Sewage Flows.

Date: October 1, 2008

To: Attendees

From: Bill Johnston, Virginia Beach Department of Public Works

Subject: **Nanney Creek Watershed**
HSPF Water Quality Model Update
Fecal Coliform Simulation

URS Corporation has been contracted by the City of Virginia Beach Department of Public Works to develop a watershed model for the Nanney Creek area. The main focus of this model is simulation of land-based fecal coliform loading and subsequent delivery to Nanney Creek. Public input is integral to accurate representation of hydrologic conditions and bacterial sources in the study area. Therefore, a public comment period was incorporated into each stage of model development: drainage, land use, and bacterial source identification.

Work to Date

- Site visits to gather land use information for each parcel visible from the road.
- Site visits to expand upon City-supplied ditch lines and to determine flow direction where possible.
- Development of a septic tank database for the study area incorporating Virginia Department of Health (VDH) septic tank data provided by Skip Scanlon (VDH) as well as homes/businesses located during site visits & review of aerial imagery.
- Graphic location and incorporation of biosolids application data provided by Rhonda Bowen (Hampton Roads Sanitation District, HRSD). HSPF modeling was conducted using HRSD Progress Farm biosolid application data to ensure accurate biosolids representation in the Nanney Creek model.
- Draft maps of area land use (at the parcel level) and drainage boundaries were displayed for public review and comment at the Farm Bureau from Wednesday, September 26th through Friday, October 19th. City personnel received a three-week review period following public comment. URS then finalized the land use and drainage maps by incorporating public and City input.

- Public comment draft maps of bacterial sources in the watershed were developed using data collected during site visits as well as responses from the public participation survey and communication with local wildlife professionals. These sources include livestock, pets, wildlife, septic tanks, and biosolids application. The public comment draft bacterial source maps were displayed for public review and comment at the Farm Bureau from Tuesday, December 11th through Friday, December 28th. Bacterial source and habitat maps were updated based on TAC input received at the January 16th meeting. The City extended the comment period to January 23rd to provide one (1) additional week for public input on bacterial sources.
- URS developed an HSPF (Hydrologic Simulation Program – Fortran) model of the study area – Virginia Beach Watershed 24 (including the Nanney Creek Basin). The model includes 221 model segments and corresponding streams. Twenty (20) independent land use categories have been represented.
- A septic system failure analysis was conducted using the HSPF model. Results of the analysis show that proximity to the creek – and not necessarily septic tank age – is the governing factor influencing the transport of human bacteria to Nanney Creek.
- The HSPF model was used to adjust and verify wildlife populations in the study area. An existing conditions simulation was developed that showed good agreement with DEQ monitoring data for the period January 3003 through December 2006. Reduction scenarios were developed which showed that removal of all anthropogenic sources would NOT lead to attainment of water quality standards.
- The City and URS met with DEQ on July 21st to discuss bacterial source populations and the resulting existing conditions simulation. Based on DEQ recommendations, additional adjustments to muskrat and deer populations were made. The final animal populations (after adjustment) were used to develop a revised existing conditions simulation.

What's Next

- URS will develop load and wasteload allocations for the area to meet water quality standards. Though reduction scenarios do not normally address reductions to wildlife loading, this effort will consider deer population management and population reduction for nuisance species.
- The HSPF model will be used to assess the effectiveness of proposed management practices and activities identified in the Implementation Plan (IP) with the goal of improving water quality in Nanney Creek.

Level of Detail and Results Comparison (TMDL vs. Current Effort)

- Drainage Patterns

  The Nanney Creek model developed for the TMDL study was composed of four (4) model segments. To develop the drainage patterns for the current effort, extensive ground-truthing was conducted. The watershed boundary was refined and subbasin boundaries defined based on topographic data, existing roadside ditch data, site observations, aerial photography, and public comment. The resulting Nanney Creek Basin is comprised of 156 model segments.

- Land Use

  The TMDL study used National Land Cover Data (NLCD) 1992 coarse-scale land use map consisting of fourteen (14) land use categories which were then consolidated to ten (10) categories. For the current effort, a parcel-level land use coverage was developed (current as of Fall 2007) using aerial imagery, zoning maps, parcel data, site visits, and public comment – resulting in twenty (20) land use categories.

- Bacterial Source Representation

  - Livestock

    The TMDL study considered horses and hogs as the predominant livestock species in the Nanney Creek Basin. Livestock populations used in the TMDL study were developed through various interviews, Confined Animal Feeding Operations (CAFO) data, and watershed visits. Livestock identification for the current effort relied heavily on public input and site visits. Besides horses and hogs, cattle, goat, and sheep populations were enumerated and included in the current effort.

  - Wildlife

    Deer, geese, ducks, muskrats, raccoons, beavers, and gulls were the wildlife species included in the TMDL study. Wildlife populations were enumerated through various interviews and literature values. For the current effort, wildlife identification relied heavily on public input, though interviews with local and state agencies were also conducted. Based on public input, the species of wildlife considered in the current effort differs from that used in the TMDL study; nutria were included in the current effort while beaver were eliminated. Public comment indicated that the deer population used in the TMDL study underestimates the actual deer population in the Nanney Creek Basin.

Therefore, several model simulations were developed to establish a realistic deer population. Results of the deer population calibration effort support a deer population significantly higher than that used in the TMDL study.

- Residential Sewage Treatment Systems

  U.S. Census data for 1990 and 2000 was extrapolated to 2004 for use in the TMDL study. The resulting number of septic tanks was 261. There were four (4) reports of "Other Means" of sewage disposal – assumed to be pit-privy or straight pipe disposal. Septic and straight pipe bacterial contributions were determined using literature values. For the current effort, a septic system database was constructed using Virginia Department of Health (VDH) data, land use information, and aerial imagery. Septic loads to the creek were determined through an independent model calibration exercise.

- Biosolids

  Biosolids were applied to the HSPF model in a similar fashion for both the TMDL study and the current effort. For the current effort, each biosolids application field within the study area was identified so that actual application rates and dates could be simulated. In addition to ensuring accurate application of biosolids within the watershed, soil improvement due to biosolids application was incorporated through the development of an independent calibration model.

- Domestic Animals

  Pet (cat and dog) populations for the TMDL study were derived from American Veterinary Medical Association (AVMA) Center for Information Management demographics for 1997. For the current effort, the cat population was not enumerated due to their extremely low application rate and fecal coliform density. Dog loads were applied to all residential land uses (including agricultural homesteads). Dog populations were determined based on the housing density for each residential land use as well as 2002 AVMA ownership data.

- Existing Conditions Assessment
    - Calibration Period

      Water quality calibration of the HSPF model developed during the TMDL study was performed over the time period February 1998 – December 1998. The current effort examines the "fit" of the model output from January 2003 through December 2006.
    - Calibration Results

      Calibration results show good agreement [for fecal coliform (FC) concentrations greater than 100 cfu/100mL] for both the TMDL study and the current effort. While all available water quality observations were used to aid in calibrating the current model, the TMDL study did not attempt to calibrate to values less than 100 cfu/100mL. *By reference, prior to June 2008, the following criteria applied to primary contact recreation uses: FC bacteria shall not exceed a geometric mean of 200 FC bacteria per 100mL of water nor shall more than 10% of samples taken during any calendar month exceed 400 FC bacteria per 100mL of water.*
    - Resulting Source Contributions

      The TMDL identified hogs (41%), waterfowl (15%), and raccoons (12%) as the major sources of bacteria in the watershed. The current effort also identified hogs as the largest single contributor in the watershed (29%) between January 2003 and December 2006 (representative modeling period). However, once the hog population has been removed from the watershed, wildlife will become the largest source of bacteria (48%); livestock will then contribute 41% of the bacteria from the watershed. Additional monitoring will be conducted to evaluate the water quality impacts of removing the former hog population from the watershed. Direct human contributions through failing or malfunctioning septic tanks and uncontrolled discharges represent less than 1% of the total existing load to Nanney Creek.

Appendix B:
Virginia Beach Southern Watersheds Management Ordinance

//Virginia Beach, Virginia/CODE City of VIRGINIA BEACH, VIRGINIA Codified through Ordinance No. 3061, adopted December 2, 2008. (Supplement No. 103, Update 1)/APPENDIX G SOUTHERN WATERSHEDS MANAGEMENT ORDINANCE*

APPENDIX G SOUTHERN WATERSHEDS MANAGEMENT ORDINANCE*

***Editor's note:** This appendix is derived from Ord. No. 2115, adopted Mar. 24, 1992. The text has been set out as adopted except for minor stylistic changes made for conformity with the remainder of this publication. Editorial emendations made for the purpose of clarity are included in brackets [ ].

Cross references: Floodplain regulations, App. A, § 1200 et seq.; wetlands zoning ordinance, App. A, 400 et seq.; coastal primary sand dune zoning ordinance, App. A, § 1600 et seq.

Sec. 1. Title.

This ordinance shall be known as the Southern Watersheds Management Ordinance of the City of Virginia Beach.

Sec. 2. Findings of fact.

(a) The watersheds of the North Landing River, the Northwest River and Back Bay, collectively referred to herein as the Southern Watersheds of the city, and the waterways they contain, constitute a unique and sensitive environment inclusive of coastal primary sand dunes, tidal wetlands, nontidal wetlands and sensitive soils.

(b) Extensive floodplains and marsh fringes bordering the waterways within the Southern Watersheds provide a unique and valuable habitat. Lands adjacent to waterways have an intrinsic water quality value due to the ecological and biological processes they perform or which occur within them.

(c) Much of the land area comprising the Southern Watersheds currently supports forestal, agricultural, recreational, and conservation activities. Any future development must be undertaken in a manner which encourages harmony among development, agriculture, recreation and conservation.

(d) The primary topographic feature characterizing the Southern Watersheds is the flatness of the lands surrounding Back Bay, the North Landing River, the Northwest River and their respective tributaries. The lack of topographic relief is a unique characteristic of the Southern Watersheds which must be considered when undertaking development and agricultural activities within the watersheds.

(e) Submerged aquatic vegetation, certain migratory waterfowl and finfish populations have seriously declined within the Back Bay watershed. Proper management of existing wetland habitats and the reestablishment of aquatic vegetation can improve habitat conditions for both migratory waterfowl and aquatic life.

(f) Back Bay is generally shallow with a few narrow channels. Wind-driven tides often inundate the lower floodplains. Wind tides, coupled with storm events, influence the physical conditions of the Bay, including salinity, suspended solids and nutrient levels.

(g) The increase of nutrients such as phosphorus and nitrogen accelerates eutrophication of receiving waters, adversely affecting plant and animal communities.

(h) Land-disturbing activities resulting in the alteration of natural topography, and removal of vegetation tends to increase erosion.

(i) Vegetated areas adjoining waterways and wetlands protect those resources by reducing the generation and transport of sediment.

(j) Indigenous ground cover, especially forested floor area, is effective in holding soil in place, thereby preventing site erosion, and in filtering stormwater runoff. By minimizing impervious cover and land disturbance, rainwater infiltration is enhanced and stormwater runoff reduced.

(k) Unstable ditch and canal banks and eroding marsh areas contribute sediment and nutrients to receiving streams.

(l) The major hydraulic pathways by which pollutants generated by agricultural activities enter receiving streams are surface runoff and groundwater discharge. The major pollutants are sediment and nutrients.

(m) For agriculture tillage and cropping systems, nutrients, animal waste management, irrigation, drainage, pest management and other factors must be considered in conjunction with each other.

(n) The implementation and assessment of agricultural best management practices (BMPs) must be performed within the framework of the entire farming system.

(o) A realistic program for the implementation of agricultural BMPs cannot be developed in the absence of a holistic assessment of BMP effectiveness and impacts, including environmental, economic, social and other motivational factors.

(p) The National Pollutant Discharge Elimination System (NPDES) Program generally requires a reduction of pollutant loads in stormwater runoff to the maximum extent practicable.

(q) Periodic water quality monitoring has indicated elevated levels of fecal coliform bacteria in several canals, connected to Back Bay, adjacent to the Sandbridge community. These canals have, in the past, been classified Class I health hazards in violation of health department standards for primary contact waters.

(r) The North Landing River from the North Carolina line to the bridge at Route 165, the Pocaty River from its junction with the North Landing River to the Blackwater Road bridge, West Neck Creek from the junction with the North Landing River to Indian River Road bridge, and Blackwater Creek from the junction with the North Landing River to the confluence, approximately 4.2 miles, of an unnamed tributary approximately 1.75 miles, more or less, west of Blackwater Road, have been designated by the Virginia General Assembly as components of the Virginia Scenic Rivers System. The wetlands of the North Landing River, Northwest River and Back Bay support high concentrations of natural heritage resources and migratory waterfowl, making this area a national conservation priority.

(s) In 1990, the United States Fish and Wildlife Service completed an environmental assessment and land protection plan that established an acquisition boundary, within which lands that are nationally important for wildlife could be purchased for inclusion in the National Wildlife Refuge System. When acquired, these environmentally sensitive lands would be managed as part of the Back Bay National Wildlife Refuge.

(t) There is not an absolute relationship between soil type and topographic elevation. Some poorly drained soils, such as Acredale, may occur both at low elevations adjacent to Back Bay and at higher elevations in the interior portions of the city. These hydric soils of different elevations are not equally suitable for development. Conversely, there are a few areas of well-drained soils that occur at relatively low elevations.

(u) Much of the area within the Southern Watersheds lies within natural areas identified in the Virginia Beach Natural Areas Inventory and contains significant natural heritage resources.

(Ord. No. 2562, 9-14-99)

Sec. 3. Objectives.

This ordinance is intended to protect, enhance and restore the quality of waters within the Southern Watersheds of the city. In order to protect, maintain, and enhance both the immediate and the long-term health, safety and general welfare of the citizens of the City of Virginia Beach, this ordinance has the following objectives:

(a) To encourage productive and enjoyable harmony among agricultural, recreational, developmental and conservation interests, and the natural resources of the city;

(b) To enhance, restore and protect the chemical, physical and biological integrity of waters within the Southern Watersheds;

(c) To encourage the construction of drainage systems which maintain or functionally approximate existing natural systems and to prevent the alteration of existing drainage systems where such activities may adversely affect water quality or natural heritage resources;

(d) To encourage the protection of watercourses and the use of them in ways which do not impair their beneficial functioning;

(e) To minimize or reduce the transport of pollutants to the waters of the Southern Watersheds;

(f) To protect groundwater;

(g) To minimize or reduce erosion and sedimentation;

(h) To prevent damage to wetlands and critical-edge habitat;

(i) To prevent damage from flooding, while recognizing that natural fluctuations in water levels are beneficial;

(j) To protect, restore and maintain plant and animal, including fish, communities in the Southern Watersheds;

(k) To improve drainage systems in a manner which promotes bank stabilization, utilizing both structural and nonstructural methods; and

(l) To sustain and accelerate accomplishments in protecting water quality by continuing education, community involvement and incentives as appropriate.

(Ord. No. 2562, 9-14-99)

Sec. 4. Definitions.

The following words and terms used in this ordinance shall have the following meanings, unless the context clearly indicates otherwise:

(a) *Agricultural lands:* Those lands used for the planting and harvesting of crops or plant growth of any kind in the open, pasture, horticulture, dairy farming, floriculture, or the raising of poultry or livestock.

(b) *Best management practice (BMP):* A practice, or combination of practices, determined to be the most effective practical means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals.

(c) *Clearing:* The removal of vegetation from surface soils.

(d) *Construction footprint:* The area of all impervious surface created by development of land, including, but not limited to, buildings, roads, construction staging areas, drives, parking areas and sidewalks, and any other land disturbed for the construction of such improvements.

(e) *Conventional tillage:* The combined primary and secondary tillage operations normally performed in preparing a seedbed for a given crop grown in a given geographical area.

(f) *Critical-edge habitat:* Those lands adjacent to wetlands and waterways that provide for flood control, water quality enhancement, wildlife use, public access and recreation, and aesthetics.

(g) *Detention:* The collection and storage of surface water for subsequent gradual discharge.

(h) *Developer:* Any person who engages in development, either as an owner, or as the agent or representative of an owner, of property.

(i) *Development:* The construction, alteration or installation of any structure or other improvement upon a parcel of land, or any land disturbance, whether or not undertaken in connection with development, but not including activities associated with agriculture or silviculture or the construction of improvements used primarily for agricultural purposes.

(j) *Drainage facility:* Any manmade or artificially altered component of the drainage system.

(k) *Drainage system:* The system through which water flows from the land, including all watercourses, water bodies and wetlands.

(l) *Erosion:* The wearing or washing away of soil by the action of wind, water or other natural processes.

(m) *Flood:* A temporary rise in the level of any water body, watercourse or wetland which results in the inundation of areas not ordinarily covered by water.

(n) *Floodplain:* That land area adjoining a river, stream, watercourse, ocean, bay, or lake, which is subject to inundation. Floodplains shall be determined as the land situated below the elevation of:

(1) That recorded by the maximum elevation of the flood water of record;

(2) The intermediate flood level as determined by the U.S. Army Corps of Engineers; or

(3) The flood level as determined by the department of public works, whichever is greater. Any changes in the delineation of the intermediate flood level are subject to approval by the federal insurance administrator.

(o) *Forebay:* An extra storage area provided near the inlet to a best management practice facility to trap incoming sediments.

(p) *Grade control structures:* A mechanical device used to collect surface water from a given elevation and outlet it at a lower elevation for purposes of minimizing erosion of a slope or ditch bank.

(q) *Hoe drain or power take-off drain:* A shallow surface drain constructed perpendicular to the orientation of rows of crops, used for the purpose of collecting and transporting excessive water.

(r) *Impervious surface:* A surface which is compacted or covered with a layer of material so that it is highly resistant to infiltration by water, including, but not limited to, most conventionally surfaced streets, roofs, sidewalks, parking lots, and other similar structures.

(s) *Land disturbance:* Any activity which causes, contributes to, or results in the removal, destruction or covering of the vegetation upon any land, including, but not limited to, clearing, dredging, filling, grading or excavating. The term shall not include minor activity such as home gardening, individual home landscaping and home maintenance.

(t) *Natural heritage resources:* Rare, threatened or endangered species and their habitat, rare or state-significant natural communities or geologic sites, and similar features of scientific interest benefiting the welfare of the citizens of the commonwealth pursuant to the Virginia Natural Area Preserves Act of 1989.

(u) *Natural system:* A system which predominantly consists of or uses those communities of plants, animals, bacteria and other flora and fauna which occur indigenously on the land, in the soil, or in the water.

(v) *Nontidal wetlands:* Those wetlands, other than tidal wetlands, that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions, as identified or referred to in the City of Virginia Beach Soil Survey by soil names Backbay Mucky Peat; Duckston portion of Corolla-Duckston Fine Sands; Dorovan Mucky Peat; Duckston Fine Sand; Nawney Silt Loam; Pamlico Mucky Peat; Rapahannock Mucky Peat, Strongly Saline or Pocaty Peat; and any other lands which under normal conditions are saturated to the ground surface and connected by surface flow and contiguous to tidal wetlands or tributary streams.

(w) *Noxious weed:* A plant which is undesirable because it conflicts with, restricts or otherwise interferes with management objectives of this ordinance, including, but not limited to, Johnsongrass, Purple Loosestrife and Shattercane.

(x) *Person:* An individual, fiduciary, corporation, firm, partnership, association, organization, municipal corporation or other entity or combination thereof.

(y) *Property line ditch:* A ditch or canal used as, or located upon, a boundary between adjacent properties in private ownership.

(z) *Receiving body:* Any water body, watercourse or wetland into which surface waters flow, either naturally, in manmade ditches or in a closed conduit system.

(aa) *Retention:* The collection and storage of runoff without subsequent discharge to surface waters.

(bb) *Sediment:* Particulate material, whether mineral or organic, that is in suspension or has settled in a water body.

(cc) *Sedimentation facility:* Any structure or area which is designed to hold runoff water until suspended sediments have settled.

(dd) *Shoreline:* The interface between land and the ordinary high-water mark.

(ee) *Silviculture:* The care and cultivation of forest trees.

(ff) *Site:* Any tract or parcel of land, or combination of tracts, lots or parcels of land which are in common ownership or are contiguous and in diverse ownership where development is to be performed as part of a subdivision or construction project.

(gg) *Structure:* That which is built or constructed, an edifice or building of any kind or any piece of work artificially built up or composed of parts joined together in some definite manner, but not including fences or signs.

(hh) *Subdivision:* The division of any parcel of land into two (2) or more lots or parcels. The term shall include all changes in lot lines, the creation of new lots involving any division of an existing lot or lots and, if a new street is involved in such division, any division of a parcel of land. When appropriate to the context, the term shall also include the process of subdividing and the territory subdivided.

(ii) *Tidal wetlands:* Vegetated and nonvegetated wetlands, as defined in section 1401 of the City Zoning Ordinance [Appendix A].

(jj) *Tillage equipment:* Farm equipment commonly used to invert the soil surface layer, including, but not limited to, disc harrows and moldboard plows.

(kk) *Tributary stream:* A watercourse contiguous to wetlands or shorelines, as defined in this ordinance.

(ll) *Vegetation:* All plant growth, including, but not limited to, trees, shrubs, vines, ferns, herbs, mosses and grasses.

(mm) *Waters or community of waters:* Any and all water on or beneath the surface of the ground, including the water in any watercourse, water body or drainage system and diffused surface water and water percolating, standing or flowing beneath the surface of the ground, as well as coastal waters.

(nn) *Watercourse:* Any natural or artificial stream, river, creek, channel, ditch, canal, conduit, culvert, drain, waterway, gully, ravine, swale or wash in which water flows, either continuously or intermittently, and which has a definite channel, bed or banks.

(oo) *Water-dependent facility:* A development of land which must be located on a shoreline by reason of its intrinsic nature, including, but not limited to, ports, intake and outfall structures of power plants, water treatment plants, sewage treatment plants, storm sewer outfalls, marinas and other boat docking structures, beaches and other public water-oriented recreational areas, fisheries or other marine resource facilities and shoreline protection measures as authorized under the provisions of the Wetlands Zoning Ordinance. [Appendix A, § 1400 et seq.]. In the case of facilities having both water-dependent components and components which are not water-dependent, only those portions which are water-dependent shall fail within this definition.

(pp) *Wetlands:* Tidal and nontidal wetlands as defined herein.

(Ord. No. 2562 9-14-99; Ord. No. 2673, 10-23-01)

Sec. 5. Applicability.

This ordinance shall apply to:

(a) Development upon any lands or waters within the watershed of the North Landing River, the Northwest River or Back Bay, which watersheds are collectively referred to herein as the Southern Watersheds;

(b) Any artificial alteration of the level or flow of any watercourse or impoundment of water; and

(c) To the extent set forth in section 10 of this ordinance, agricultural activities within the Southern Watersheds.

(Ord. No. 2603, 7-14-2000)

Sec. 6. Exemptions.

The following activities shall be exempt from the provisions of this ordinance:

(a) Maintenance, alterations or improvements of existing structures not affecting the quality, rate, volume or location of surface water discharge or significantly altering the characteristics of natural or manmade drainage systems; provided, however, that any such activity resulting in a land disturbance exceeding an area of two thousand five hundred (2,500) square feet shall be required to comply with the erosion and sediment control requirements set forth in sections 30-56 through 30-78 of the City Code; [and]

(b) Development upon any lot or parcel of land lawfully created and located within a residential zoning district permitting single-family dwellings or duplexes as a matter of right prior to the date of adoption of this ordinance [March 24, 1992]; and

(c) Construction, installation, operation and maintenance of water, sewer, electric, telephone, cable and gas lines and their appurtenant structures, provided that:

(1) To the greatest practicable degree, the location of such facilities shall be located outside of and no less than fifty (50) feet from wetlands and shorelines;

(2) No greater area of land shall be disturbed than is necessary;

(3) The construction, installation, operation and maintenance of such facilities shall comply with all applicable state and federal requirements and shall be designed and constructed in a manner which minimizes adverse effects upon water quality; and

(4) Any land disturbance exceeding an area of two thousand five hundred (2,500) square feet shall comply with the erosion and sediment control requirements set forth in sections 30-56 through 30-78 of the City Code; and

(d) Silvicultural activities, provided that such activities comply with all applicable city, state and federal requirements.

(Ord. No. 2562, 9-14-99; Ord. No. 2603, 7-14-2000)

Sec. 7. Performance standards.

(a) Development resulting in or requiring a land disturbance exceeding an area of two thousand five hundred (2,500) square feet shall comply with the erosion and sediment control requirements set forth in sections 30-56 through 30-78 of the City Code.

(b) On lots greater than or equal to one (1) acre in area and not served by the public sewer system, a reserve sewage disposal drainfield site with a capacity at least equal to that of the primary sewage disposal drainfield site shall be provided unless, in the judgment of the Virginia Beach Health District of the Virginia Health Department, the area of such lot is insufficient to accommodate such reserve drainfield site. On lots subject to the criteria for septic tank installation in poorly drained soils, a reserve sewage disposal drainfield site with a capacity no less than one-half of the primary sewage disposal drainfield site shall be provided unless, in the judgment of the Virginia Beach Health District of the Virginia Health Department, the area of such lot is insufficient to accommodate such reserve drainfield site. The construction or installation of any impervious surface shall be prohibited on the area of all sewage disposal drainfield sites, including reserve drainfield sites, until the property is served by the public sewer system.

(c) Development in, or within fifty (50) feet of, any wetland or shoreline, except wetlands or shorelines established in connection with structural best management practice facilities, shall be prohibited; provided, however, that vegetation may be cleared for the establishment of access paths if such removal is undertaken in a manner which minimizes land disturbance and impacts to remaining vegetation and maintains the functional value of the fifty-foot area as a stormwater filter; and provided further, that water-dependent facilities may be located within such area. Public highways may be constructed in or across wetlands or shorelines or within fifty (50) feet thereof under the following conditions:

(1) Any land-disturbing activity associated with such construction shall be in compliance with the erosion and sediment control requirements set forth in sections 30-56 through 30-78 of the City Code, or in the case of state agency projects, with such conservation plan or erosion and sediment control specifications as may be approved by the department of conservation and recreation;

(2) There is no practicable alternative location which would have less adverse impact on wetlands or waters within the Southern Watersheds, taking into consideration cost, existing technology, and logistics in light of overall project purposes; and

(3) Appropriate and practicable measures are taken to minimize potential adverse effects of such construction, including any discharge of material associated therewith, on wetlands or waters within the Southern Watersheds.

(d) The following design criteria shall apply to the fifty-foot area described in subsection (c):

(1) Such area shall consist of a mixture of indigenous evergreen and deciduous trees, grass and shrubs;

(2) Trees and shrubs, which may be of seedling variety, shall be planted on ten-foot centers; and

(3) Except as allowed in subsection (c), vegetation located in such area shall not be cleared, cut or mown.

(e) The following additional performance standards shall be requirements of all development, except single-family dwellings or duplexes separately built and not part of a subdivision:

(1) After development, runoff from the site shall approximate the rate of flow and timing of runoff that would have occurred following the same rainfall under predevelopment conditions and, to the extent practicable, natural conditions, unless runoff is discharged into a regional BMP facility;

(2) Measures ensuring compliance with the following design storm event criteria shall be incorporated:

TABLE INSET:

Parcel Size	Design Storm Event
Less than 300 acres	10-year storm
300 to 500 acres	25-year storm
Greater than 500 acres	50-year storm

(3) The natural hydrodynamic characteristics of the watershed shall be maintained to the greatest extent practicable.

(f) The following additional performance standards shall be requirements of all development:

(1) The quality of surface waters and groundwater shall be protected and, where practicable, enhanced;

(2) Erosion during and after development shall be minimized;

(3) Groundwater levels shall be protected;

(4) The beneficial functioning of wetlands as areas for the natural storage of surface waters and the chemical reduction and assimilation of pollutants shall be protected;

(5) The location, construction or design or structures in areas prone to flooding shall be undertaken in such manner as to prevent increased flooding and damage resulting from such development;

(6) Salt water intrusion shall be prevented or minimized;

(7) Natural fluctuations in salinity levels in estuarine areas shall not be altered;

(8) Land disturbance shall be minimized; and

(9) Injury to plant and animal communities and adverse impacts upon fish and wildlife habitat shall be minimized.

(Ord. No. 2562, 9-14-99)

Sec. 8. Design criteria.

In order to ensure that the objectives of this ordinance and the performance standards set forth hereinabove will be attained, development subject to the provisions of section 7(e) shall be in accordance with the following requirements, which shall be in addition to the requirements of subsections (a), (b), (c) and (d) of section 7:

(a) Channeling runoff directly into water bodies shall be prohibited; and stormwater runoff shall be routed through systems designed to increase time of concentration, decrease velocity, increase infiltration, allow suspended solids to settle and remove pollutants;

(b) Watercourses shall not be dredged, cleared of vegetation, deepened, widened, straightened, stabilized or otherwise altered, except for the purpose of governmental flood control or water quality projects or normal maintenance. Maintenance of such watercourses shall be in accordance with the erosion and sediment control requirements of sections 30-56 through 30-78 of the City Code;

(c) Water shall be retained or detained before it enters any watercourse in order to prevent siltation or other pollution;

(d) Streambank erosion control shall be designed so as to meet or exceed the minimum state stormwater management criteria, which require that stormwater runoff be discharged into a channel which conveys runoff from a two-year storm event without flooding or erosion;

(e) The area of land disturbed by development shall be as small as practicable. Those areas which are not to be disturbed shall be protected from construction activity by adequate barriers. Whenever practicable, existing vegetation shall be retained and protected on the development site;

(f) Wetlands and watercourses shall not be used as sediment traps;

(g) Erosion and sedimentation facilities shall receive maintenance as prescribed by the approved management plan required by section 9 of this ordinance;

(h) Artificial watercourses shall be designed to reflect the degree of erodibility of soil types through which such watercourses are constructed and to result in flow velocities sufficiently low to prevent erosion of the banks or bed of such watercourses;

(i) Stormwater management ponds shall be used to detain or retain the increased and accelerated runoff generated by development and shall remove pollutants in stormwater to the maximum extent practicable. Water shall be released from detention pond into watercourse or wetlands at a rate and in a manner approximating the natural flow which would have occurred before development;

(j) The use of wetlands for storing and purifying water may be used as the final treatment as part of a comprehensive stormwater management plan, provided their capacity is not overloaded, thereby harming the wetlands and transitional vegetation. Wetlands shall not be damaged by the construction of stormwater management systems;

(k) Structural best management practice (BMP) facilities shall not be used as sediment traps during construction unless so designed and approved in accordance with the construction plans;

(l) No structural best management practice (BMP) facility shall be constructed within the one hundred-year floodplain;

(m) The use of multiple best management practice (BMP) facilities, both structural and nonstructural, is encouraged;

(n) Stormwater management facilities incorporating the following design criteria are encouraged:

(1) Retention areas should be designed so that maintenance necessitated from siltation deposition is easily achieved. Forebay areas should be constructed at each stormwater inflow site, and an emergent wetlands bench should be established around the forebay perimeter;

(2) Retention areas should include an emergent wetlands bench area around the perimeter of the facility. Shorelines shall be designed so that benched areas are winding rather than straight, thereby maximizing the length of shoreline and offering more space for the growth of emergent vegetation;

(3) Retention areas and borrow pit operations should be designed to include a dewatering facility to capture all sediment;

(4) Maintenance access routes should be provided to all structural best management practice (BMP) facilities;

(5) Retention area facilities should include the planting of grasses and herbaceous and woody vegetation along the perimeter of such facilities to improve aesthetics and below the top of bank to promote water quality improvement; and

(6) Infiltration facilities should not be located under areas of impervious cover; and

(o) Stormwater, wastewater and potable water supply facilities and facilities used for the underground storage of petroleum products shall be designed and located so as to optimize water quality benefits while protecting potable water supplies.

(Ord. No. 2673, 10-23-01)

Sec. 9. Southern Watersheds Management Plan.

(a) The developer of any land within the Southern Watersheds shall, prior to undertaking any land-disturbing activity, submit a Southern Watersheds Management Plan if such development is subject to the requirements of section 7(e) hereof. No such land-disturbing activity shall take place until the plan is approved and all required permits and approvals have been granted. There shall be included in the plan sufficient information for the development services center and the departments of planning, agriculture and public works to evaluate the environmental characteristics of the affected areas, the potential and predicted impacts of the proposed activity on waters and wetlands within the Southern Watersheds and the effectiveness and acceptability of those measures proposed by the applicant for preventing or minimizing adverse impacts. The plan shall contain maps, charts, graphs, tables, photographs, narrative descriptions and explanations and citations to supporting references, as appropriate, to communicate the information required by this section.

(b) The plan shall contain the name, address and telephone number of the owner of the property sought to be developed and the developer of such property and a statement signed by the owner indicating his or her consent to the proposed development. In addition, the legal description of the property shall be provided and its location with reference to such landmarks as major water bodies, adjoining roads, railroads or subdivisions shall be clearly identified by a map.

(c) The plan shall include a detailed description of the existing environmental and hydrologic conditions of the site and receiving waters, including the following information as appropriate to the circumstances:

(1) The direction, flow rate and volume of stormwater runoff under existing conditions;

(2) The location of areas on the site where stormwater collects or percolates into the ground;

(3) A description of all watercourses, water bodies and wetlands on or adjacent to the site or into which stormwater flows. Information regarding their water quality and the current water quality classification, if any, given them by the Virginia Water Control Board shall be included;

(4) Groundwater levels, as indicated by the Virginia Beach Soil Survey;

(5) Location of floodplains, including floodways and flood fringes;

(6) Identification of vegetation existing on the site;

(7) The topography of the site; and

(8) Soil types or taxonomic units existing on the site.

(d) Proposed alterations of any site containing, or adjacent to, a wetland or shoreline shall be prescribed in detail. Such description shall address:

(1) Changes in topography resulting from development;

(2) Areas where vegetation will be cleared or killed;

(3) Areas to be covered with impervious surfaces, including a description of the surfacing material; and

(4) The size, location and proposed use of any buildings or other structures.

(e) Predicted impacts of the proposed development on existing conditions shall be described in detail. Such description shall address:

(1) Changes in water quality;

(2) Changes in groundwater levels;

(3) Changes in the incidence and duration of flooding on the site and upstream and downstream from it; and

(4) Impacts on wetlands and natural heritage resources.

(f) A plan for the control of stormwater runoff, identifying all components of the drainage system and any measures for the detention, retention or infiltration of water, shall be described in detail.

(g) The location of on-site potable water wells and wastewater facilities shall be identified.

(h) A plan for the maintenance of best management practice facilities.

(i) Erosion and sedimentation facilities shall be maintained in accordance with the Virginia Erosion and Sediment Control Handbook.

(j) Stormwater management facilities shall be inspected twice each year and following every storm which causes the capacity of the facility to be exceeded to ensure that the facility remains operational. Any failures shall be corrected immediately.

(k) The plan shall include any other information which the developer or the departments of planning and public works believe is reasonably necessary for an evaluation of impacts of the development upon water quality.

(Ord. No. 2562, 9-14-99)

Sec. 10. Agricultural lands.

(a) Persons engaged in agricultural activities are encouraged to explore and make use of all available resources offered in connection with the conversation of agricultural lands, including personal contacts, on-site field studies concerning the usage of potential agricultural best management practices, focused educational programs, demonstration and education projects, cost-share incentives and technical assistance provided by city, state and federal resource agencies.

(b) The director of the department of agriculture, in concert with the Virginia Department of Agriculture and Consumer Services, Virginia Department of Forestry and the United States Department of Agriculture, Soil Conversation Service, shall coordinate the exploration of all available resources as described in section 10(a) of this ordinance. The director shall maintain a record of all efforts relating to the development of individual farm conservation plans, cost-share incentives, focused educational programs and the development and implementation of agricultural best management facility projects, and shall report thereupon every six (6) months to the city council.

(Ord. No. 2562, 9-14-99)

Sec. 11. Procedures.

(a) A presubmittal meeting with the development services center to discuss the project in order to facilitate the development review process is encouraged.

(b) A processing fee shall be collected at the time the Southern Watersheds Plan is submitted, which fee shall defray the cost of administration of this ordinance, including costs associated with plan review, issuance of permits, periodic inspection for compliance with approved plans, and necessary enforcement. Such fee shall be in an amount equal to the fee required by section 7 of the Stormwater Management Ordinance [Appendix D].

(c) Within sixty (60) working days after submission of the completed Southern Watersheds Plan, the development services center shall approve the plan, with or without specified conditions or modifications, or reject the plan, and shall notify the applicant accordingly. If the development services center has not rendered a decision within sixty (60) working days after submission of the plan, the plan shall be deemed approved and the applicant shall be authorized to proceed with the proposed activity. If the plan is rejected or modified, the development services center shall specify such modifications, terms or conditions as will allow approval of the plan; provided, however, that it shall not be the responsibility of the development services center to design an acceptable project.

[(d), (e) *Reserved.*]

(f) The Southern Watersheds Management Plan shall not be approved unless it clearly indicates that the proposed development meets all requirements of this ordinance, except such requirements as have been deleted or modified pursuant to variance.

(g) *Inspections:* No Southern Watersheds Management Plan shall be approved without adequate provision for inspection of the property, as follows:

(1) *Initial inspection:* prior to approval of the management plan;

(2) *Bury inspection:* prior to burial of any underground drainage structure;

(3) *Erosion control inspection:* prior to any land-disturbing activity and as deemed necessary thereafter to ensure effective control of erosion and sedimentation; and

(4) *Finish inspection:* at such time as all land-disturbing or development activities have been completed.

Sec. 12. Variances and appeals.

(a) The city manager or his designee may authorize in specific cases a variance from any retirement of this ordinance which will not be contrary to the public interest when, by reason of the existence of special conditions, a strict enforcement of such requirement will result in unnecessary hardship. No variance shall be authorized unless:

(1) Strict application of the ordinance will produce undue hardship;

(2) The condition giving rise to the asserted hardship is not of so general or recurring nature as to make reasonably practicable the formulation of general regulations to be adopted as an amendment to the ordinance; and

(3) The granting of the variance will not:

(i) Adversely change the rate or volume of stormwater runoff;

(ii) Have an adverse impact on a wetland, shoreline, watercourse or water body;

(iii) Contribute to the degradation of water quality;

(iv) Be of substantial detriment to adjacent property or adversely affect the character of adjoining neighborhoods; or

(v) Otherwise impair attainment of the objectives of this ordinance.

When a variance is granted, the city manager or his designee may attach such conditions and safeguards as are deemed necessary to protect water quality in the Southern Watersheds, and may require a guarantee or bond to assure compliance. Any person aggrieved of the decision of the city manager or his designee may appeal such decision to the city council within thirty (30) days of the date of such decision. Any person aggrieved of a decision of the city council may appeal such decision to the circuit court within thirty (30) days of the date of such decision. Review of such decision shall be in accordance with the procedures and standards of the Administrative Process Act. The city manager or his designee shall maintain a record of all variance actions and report thereupon biannually to the city council.

(b) Any decision, determination or order made by any officer in the administration or enforcement of this ordinance may be appealed to the city council within thirty (30) days from the date of such decision, determination or order. Any decision of the city council may be appealed to the circuit court within thirty (30) days of the date of such decision. Review of such decision shall be in accordance with the procedures and standards of the Administrative Process Act.

Sec. 13. Severability.

The provisions of this ordinance shall be deemed severable; and if any of the provisions hereof are adjudged to be invalid or unenforceable, the remaining portions of this ordinance shall remain in full force and effect and their validity unimpaired.

Sec. 14. Enforcement.

(a) Any development commenced without the prior approval of a Southern Watersheds Management Plan or which is conducted contrary to such approved plan shall be deemed a public nuisance and may be enjoined or abated by the city in a manner provided by law without the necessity of showing that no adequate remedy at law exists.

(b) In addition to any other penalty or remedy herein provided, any person convicted of violating any of the provisions of this ordinance shall be punished by a fine of not more than one thousand dollars ($1,000.00) or by confinement in jail for a period of not more than thirty (30) days, either or both.

(c) Without limiting the remedies which may be obtained pursuant to this section, the city may bring a civil action against any person for a violation of any of the provisions of this ordinance. Such action may seek the imposition of a civil penalty of not more than two thousand dollars ($2,000.00) for each violation.

(d) With the consent of any person who has violated or failed, neglected or refused to comply with any of the provisions of this ordinance, the city manager or his designee may provide, in an order issued by him against such person, for the payment of a civil charge of not more than two thousand dollars ($2,000.00); provided, however, that such order shall not excuse compliance with any of the provisions of this ordinance. Monies collected pursuant to this subsection shall be dedicated to the natural resources conversation and restoration fund.

(e) Prior to the approval of any Southern Watersheds Management Plan, there shall be required of the applicant a reasonable performance bond, cash escrow, letter of credit or other legal surety or combination thereof acceptable to the city attorney to ensure that measures may be taken by the city, at the applicant's expense, should he fail, after reasonable notice, within the time specified in such notice, to comply with the requirements of this ordinance. Within sixty (60) days after final inspection of the development activity, such surety, or the unexpended or unobligated portion thereof, shall be returned to the applicant or terminated, as the case may be.

(f) Upon notice from the city manager or his designee that any activity is being conducted in violation of any of the provisions of this ordinance, such activity shall immediately be stopped. An order to stop work shall be in writing and shall state the nature of the violation and the conditions under which activity may be resumed. No such order shall take effect until it has been tendered to the owner of the property upon which the activity is conducted or his agent or to the person conducting such activity. Any person who continues an activity ordered to be stopped, except as directed in the stop-work order, shall be guilty of a violation of this ordinance.

Sec. 15. Vested rights.

The provisions of this ordinance shall not affect the vested rights of any person under existing law.

Sec. 16. Effective date.

This ordinance shall become effective on the date of its adoption.

Adopted by the Council of the City of Virginia Beach on the 24th day of March, 1989.